An Assessment of Canadian Wildlife Service Contaminant Monitoring Programs

B.M. Braune, C.E. Hebert, L.S. Benedetti, B.J. Malone

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An Assessment of Canadian Wildlife Service Contaminant Monitoring Programs

B.M. Braune[1], C.E. Hebert[1], L.S. Benedetti[1], B.J. Malone[2]

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Headquarters 2003
Canadian Wildlife Service

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Executive Summary

The Canadian Wildlife Service (CWS) is the responsible Canadian agency for management of migratory birds and other wildlife of federal interest. One aspect of that responsibility is the protection of the environment from threats caused by pollution and other natural and man-made hazards. Monitoring activities are undertaken in order to ensure that wildlife populations and communities are healthy, sustainable and maintained within desired abundances and distribution limits. There are basically two types of programs which monitor environmental stressors (e.g. contaminants): (i) baseline trend monitoring which is used to characterize baseline conditions and detect changes in environmental stressors; and (ii) programs designed to monitor stressed wildlife populations to determine what factors may be causing stress in those populations. Both types of programs are relevant to how CWS is addressing contaminant issues in Canadian wildlife.

In this report, we discuss the selection of indicator species, the design of monitoring programs to ensure their efficacy, and the relevance of CWS contaminant monitoring programs to evaluating the impact of chemical stressors on wildlife. We assess current and past CWS contaminant monitoring activities in the context of other Canadian programs monitoring contaminants in wildlife. The first phase of the assessment involved the creation of a searchable database containing information mainly on Canadian and Canadian-U.S. bilateral programs monitoring contaminants in biota. The database contains detailed information on program descriptions, monitoring locations, and publications resulting from each program. The second phase of the assessment involved the development of a "user friendly" custom graphical interface to allow mapping of the database using Geographic Information System (GIS) software. An interface with the GIS package allows creation of maps of Canadian contaminant monitoring programs based on selection of any combination of taxa, tissue type, contaminant type, specific contaminants, program status and responsible agency. The complete database and associated mapping program as well as detailed instructions for installation procedures and basic operation of the program are contained on the CD in the back pocket of this report.

Long-term contaminant monitoring programs provide important data that allow us to evaluate our impact on the environment. The monitoring of targeted chemicals, contaminant effects and species/ecosystem health are all necessary to provide an integrated program directed at understanding the role of contaminants with respect to wildlife and ecosystem health. We conclude that continuation of these monitoring programs into the foreseeable future should be a priority and program enhancement should be considered in light of program objectives.

Recommendations for program enhancement include:

- Increasing the frequency of sampling for those programs not sampling on an annual basis
- Where possible, and where population numbers permit, collection of adult specimens every eight or ten years to provide tissues for analyses of metals and new contaminants, as well as other research
- Better integration of population and contaminants monitoring programs
- Better integration of contaminant effects research with research evaluating the relative importance of other stressors, e.g. disease, food availability
- Revival on a limited basis of monitoring programs targeting species such as raptors and reptiles to maintain the potential to address future issues in terrestrial and riparian ecosystems
- Assessing the need for the addition of programs outside of the Great Lakes Basin to monitor contaminants in terrestrial and freshwater ecosystems across Canada

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Résumé Administratif

Le Service canadien de la faune (SCF) est l'organisme canadien responsable de la gestion des oiseaux migrateurs et d'autres espèces sauvages d'intérêt fédéral. Un aspect de cette responsabilité est la protection de l'environnement contre les menaces attribuables à la pollution et à d'autres dangers naturels et d'origine humaine. Des activités de surveillance sont entreprises pour faire en sorte que les populations et les communautés d'espèces sauvages sont en santé, qu'elles sont durables et qu'elles demeurent dans les limites désirées d'abondance et de répartition. Il existe fondamentalement deux types de programmes qui assurent la surveillance des agents stressants environnementaux (p. ex. les contaminants) : i) la surveillance des tendances de base, laquelle sert à caractériser les conditions de base et à déceler les changements survenus dans les agents stressants, et ii) les programmes conçus pour surveiller les populations perturbées d'espèces sauvages afin de déterminer les facteurs qui peuvent être à l'origine du stress chez ces populations. Les deux types de programmes sont pertinents en ce qui concerne la manière dont le SCF relève les problèmes de contaminants chez les espèces sauvages du Canada.

Le présent rapport porte sur la sélection des espèces indicatrices, la conception de programmes de surveillance afin d'assurer leur efficacité, et la pertinence des programmes de surveillance des contaminants du SCF, afin d'évaluer l'incidence des agents stressants chimiques sur les espèces sauvages. Nous évaluons les activités actuelles et passées du SCF relatives à la surveillance des contaminants dans le contexte d'autres programmes canadiens de surveillance des contaminants chez les espèces sauvages. La première phase de l'évaluation touchait la création d'une base de données consultable contenant surtout de l'information sur les programmes bilatéraux canadiens et canado-américains de surveillance des contaminants dans le biote. La base de données contient de l'information détaillée sur les descriptions de programmes, les lieux de surveillance et les publications découlant de chaque programme. La seconde phase de l'évaluation portait sur l'élaboration d'une interface graphique conviviale personnalisée pour permettre la cartographie de la base de données à l'aide du logiciel du Système d'information géographique (SIG). Une interface comprenant le progiciel du SIG permet de créer des cartes des programmes de surveillance des contaminants du Canada d'après une sélection de nombreuses combinaisons de taxons, de types de tissus, de types de contaminants, de contaminants précis, de l'état du programme et de l'organisme responsable. La base de donnée entière, le programme de cartographie afférent de même que les instructions détaillées des procédures d'installation et de fonctionnement de base du programme se trouvent sur un disque compact dans la pochette arrière du présent rapport.

Les programmes de surveillance à long terme des contaminants fournissent des données importantes qui nous permettent d'évaluer notre incidence sur l'environnement. La surveillance de produits chimiques ciblés, des effets des contaminants et de la santé des espèces et des écosystèmes est nécessaire à la prestation d'un programme intégré, orienté vers une compréhension du rôle des contaminants en ce qui concerne la santé des espèces sauvages et des écosystèmes. Nous arrivons à la conclusion que le maintien de ces programmes de surveillance dans un avenir prévisible devrait être une priorité et que l'amélioration des programmes devrait être considérée compte tenu des objectifs des programmes.

Les recommandations visant l'amélioration des programmes sont notamment :

- une fréquence accrue des prélèvements d'échantillons pour les programmes qui ne le font pas annuellement;
- là où c'est possible et où les effectifs de population le permettent, une collecte de spécimens adultes tous les huit à dix ans afin d'obtenir des tissus pour l'analyse des métaux et des nouveaux contaminants, de même que pour d'autres recherches;
- une meilleure intégration des programmes de surveillance des populations et des contaminants;
- une meilleure intégration des recherches sur les effets des contaminants et des recherches visant à évaluer l'importance relative d'autres agents stressants, p. ex. les maladies et la disponibilité de la nourriture;
- la reprise d'un nombre limité de programmes de surveillance visant des espèces, comme les rapaces et les reptiles, afin de maintenir la possibilité de relever à l'avenir des problèmes liés aux écosystèmes terrestres et riverains;
- une évaluation du besoin d'ajouter des programmes à l'extérieur du bassin des Grands Lacs pour surveiller les contaminants dans les écosystèmes terrestres et dulcicoles partout au Canada.

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1. Introduction

The concept of monitoring, in general, as conducted by Environment Canada is described in a Status and Trends Monitoring and Reporting Paper (Environment Canada 2000) prepared by Environment Canada's Environmental Quality Branch. The following excerpts are taken from that document:

"Monitoring is repeated observation, through time, of selected parameters to determine the state of systems. Monitoring provides information about complicated and complex systems and the effects of disturbances on those systems. Monitoring serves as an ***early warning mechanism*** *to trigger management response or further research. The key purpose of monitoring is to serve as the feedback mechanism that provides information on ecological integrity and to assist in determining whether or not a specific management action or policy has implications for ecological integrity." (Parks Canada, 1999). A properly designed monitoring program is capable of detecting patterns within the ecosystem, identifying trends in the state or condition of the ecosystem, and can provide inferences as to the cause or causes of observed trends. Combined with research results, monitoring is critical for informed decision-making by individuals, organizations and governments.*

Status and Trends Monitoring and Research

Ecosystem health status and trends monitoring is only part of the framework to detect and assess ecosystem changes and their potential consequences - and cannot function in isolation. The integration of ecosystem health status and trends monitoring and research represents an important linkage and feedback loop within an environmental assessment framework (Cash et al. 1996). Monitoring information is essential to the reporting of trends and changes in ecosystems and in the generation of hypotheses that ***could*** *provide explanation of such trends. Status and trends monitoring generally cannot test the hypothesis or determine the underlying cause of observed trends or patterns (Why it is Happening?). Therefore, it is critically important to have*

close linkages to research, to ensure that results from both activities complement one another - leading to improved data collection and enhanced predictive capability for both activities.

Monitoring is undertaken for a variety of reasons. It is carried out to:

I. characterize baseline conditions,
II. detect change,
III. describe status and trends,
IV. increase long-term understanding and prediction of ecosystem processes,
V. act as a basis for resource management,
VI. to meet mandated obligations.

It is generally carried out by a multiplicity of organizations with various aims. The majority of the monitoring is conducted to ensure compliance with environmental policies - to provide information on the effectiveness of policies already implemented or to promote the need for new or modified policies or actions. The latter is particularly important in cases where early warnings of environmental changes have been recognized.

There is growing interest and demand, nationally and internationally in monitoring environmental changes. This is especially true as the scientific literature documents human-induced changes at the global scale, such as climate change, atmospheric composition and land use changes. These situations frequently result from decisions made at the national and regional scale, and global threats can be intensified by local factors."

The Minister of Environment has legal statutory obligations under the *Canadian Environmental Protection Act (CEPA)*, and the *Migratory Birds Convention Act (MBCA)* to protect the health of Canadians and the environment from threats caused by pollution and other natural and man-made hazards. For example, CEPA 1999 obligates the Minister to establish a system for monitoring environmental quality and gather information on all aspects of toxic substances such as hormone disrupting substances. In addition to our statutory legislative obligations to environmental and

human health protection, there remains high public expectation to conduct these activities and communicate the findings. The Canadian Wildlife Service (CWS) is the responsible Canadian agency for management of migratory birds and other wildlife of federal interest. Monitoring activities were undertaken in order to ensure that wildlife populations and communities are healthy, sustainable and maintained within desired abundances and distribution limits.

There are basically two types of programs which monitor environmental stressors: (i) baseline trend monitoring which monitors stressors such as contaminants, and (ii) programs designed to monitor stressed wildlife populations. The first type is described in Environment Canada's Status and Trends Monitoring and Reporting Paper (Environment Canada 2000) and its objectives include characterization of baseline conditions, detection of change in environmental stressors, description of status and trends, and increased understanding and prediction of ecosystem processes. The second type of monitoring program evolves out of the need to determine what factors may be causing stress in wildlife populations. Both types of programs are relevant to how CWS is addressing contaminant issues in Canadian wildlife.

(i) Baseline Trend Monitoring - Baseline contaminant trend monitoring is used to characterize existing contaminant concentrations which may or may not be at background levels. This type of monitoring is designed to detect any changes in contaminant levels in the environment. The choice of monitoring location, species and tissue depends on the specific monitoring objectives. If the objective is to monitor a terrestrial, freshwater or marine environment, in general, one would ideally choose an upper trophic level species which ranges widely throughout the chosen environment so as to act as a representative integrator of contaminants in that environment. The extent of the region to be monitored (e.g. arctic marine environment vs. a specific bay) will also determine which species is best suited given that home ranges and migratory patterns vary widely among species. The indicator species chosen should be reasonably insensitive to toxicological effects and should be gregarious in nature so as to reduce variability in the sample population. Choice of tissue must take into account the pharmacokinetics of the contaminant being monitored as well as ethical considerations. A less intrusive monitoring methodology, if possible, is clearly more desirable, particularly in a long-term monitoring program.

(ii) Monitoring Stressed Populations - Monitoring of a stressed population is generally combined with investigative or research efforts, first to identify and then to monitor the contaminant(s) acting as the stressor.

It is this second type of premise for monitoring which acted as the catalyst for most CWS contaminant monitoring activities. CWS contaminant monitoring programs evolved in the late 1960s and early 1970s in response to evidence of widespread avian mortality, reproductive failure and other damage attributed to chemicals in certain contaminated systems such as the Great Lakes. As a result, we now have a number of long-term data sets on a variety of chemical stressors as well as archived samples available for retrospective surveys.

2. CWS Contaminant Monitoring Programs

2.1 Choice of Sampling Medium

CWS has maintained long-term chemical monitoring of herring gulls (*Larus argentatus*) in the Great Lakes as well as a variety of seabird species on the Atlantic and Pacific coasts, and more sporadically, seabirds and polar bears (*Ursus maritimus*) in the Arctic. Although there were programs to monitor contaminants in the terrestrial environment (see Figure 9), ongoing CWS monitoring programs focus on the aquatic environment (Figure 8). It is generally accepted that terrestrial food chains are shorter than aquatic/marine food chains. With fewer levels in the food chain, there is less biomagnification of contaminants in the terrestrial environment. Therefore, top predators in the marine environment are likely to reflect higher concentrations of biomagnifying contaminants than their equivalents in the terrestrial environment.

Gilbertson et al. (1987) evaluated the use of seabirds as indicators of marine pollution. They reviewed the criteria for selecting indicator species already described under *Baseline Trend Monitoring* and determined that many species of fish, marine mammals and seabirds meet most of the criteria. Seabirds, however, seem to be particularly good integrators of persistent chemicals in large oceanic systems given that they are long-lived; they feed at a variety of trophic levels

allowing for the monitoring of different marine compartments; and the female birds readily deposit lipophilic contaminants (Mineau et al. 1984), including mercury (Fimreite 1979; Lewis and Furness 1993), into their eggs. Many of the species are colonial nesters which facilitates the sampling of eggs. Relaying of eggs is likely and given that only a small percentage of eggs produce chicks that survive to adulthood, the collection of eggs for the monitoring of chemical contaminants constitutes a minimally intrusive method of obtaining information. As well, egg-laying is a fixed seasonal event minimizing the influence of seasonal variation and given that only adult females lay eggs, the influence of sex, and possibly age, is also minimized. In their study of organochlorine concentrations in known-age female ospreys (*Pandion haliaetus*), Ewins et al. (1999) showed that, in general, organochlorine concentrations in female ospreys reached a life-time equilibrium level by the age of first breeding (3-4 years) and therefore, the eggs from any female osprey could provide a consistent indication of organochlorine uptake, independent of the bird's age. Van den Brink et al. (1998) also showed that age-dependent accumulation of organochlorines appeared to reach a steady state in Adélie penguins (*Pygoscelis adeliae*) and southern fulmars (*Fulmaris glacialoides*) before the age of breeding, and therefore no correction for age differences is required for adults.

Gilberston et al. (1987) suggested that, in order for a species to be useful for monitoring temporal trends of contaminants, the within-collection variation must be small enough for changes to be readily detected. This means increasing the sample size in order to increase the reliability of the estimate. By calculating a coefficient of variation (CV) for PCBs and DDE in a variety of marine species, Gilbertson et al. (1987) showed that, despite higher residue levels and a somewhat larger sample size of seals, CV values were twice those found in seabirds, and CV values in fish were much higher still, even when the sample size was much larger than that for seabirds. Therefore, from the viewpoint of the number of samples needed to obtain statistical reliability, seabird eggs were shown to be superior to marine mammals or fish.

2.1.1 Do we need more than one indicator species?

For reporting purposes, Environment Canada has selected the double-crested cormorant (*Phalacrocorax auritus*) as the national indicator species for organochlorine levels in biota. It was chosen because of its broad distribution across southern Canada, including areas of concentrated human activity, and because it is a top predator that eats fish (Environment Canada 1993). The selection of cormorants has one disadvantage. With the exception of Pacific coastal populations, they migrate south in winter and may, therefore, accumulate contaminants elsewhere. As well, double-crested cormorants may have a greater metabolic capacity to eliminate some contaminants than do other species such as Caspian terns (*Sterna caspia*) (Yamashita et al. 1993). In light of what we know regarding inter-specific differences in contaminant uptake and metabolism, the difficulty associated with selecting one species as "the" indicator of contaminant availability is underscored. Different species may integrate environmental conditions in different ways necessitating a multi-species approach to environmental assessment.

Marine ecosystems, and threats to them, are sufficiently diverse that indices appropriate in one situation may not work in another and, therefore, monitoring programs need to include a variety of indices appropriate to the site, the region, and to national/regional program goals (Harding 1992). There are, or have been in the past, multiple contaminant monitoring programs in effect in areas such as the Great Lakes where monitoring of spottail shiners (*Notropis hudsonius*) (Suns et al. 1993), lake trout (*Salvelinus namaycush*) (Borgmann and Whittle 1991) and walleye (*Stizostedion vitreum*) (Hesselberg and Gannon 1995) paralleled the herring gull monitoring program, and in the Arctic, where sporadic monitoring of ringed seals (*Phoca hispida*), beluga (*Delphinapterus leucas*) and narwhal (*Monodon monoceros*) have been undertaken (Wagemann et al. 1996; Addison and Smith 1998) in conjunction with the seabird monitoring program. Monitoring of contaminants in blue mussels (*Mytilus edulis*) (Chase et al. 2001) and grey seals (*Halichoerus grypus*) (Addison and Stobo 2001) on the Atlantic coast, and in harbour seals (*Phoca vitulina*) on the Pacific coast (Peter Ross, DFO, pers. comm.), also parallel the CWS coastal seabird monitoring programs.

The monitoring of multiple species in a particular area may or may not yield parallel results. For example, in the Great Lakes, a dramatic decrease in concentrations of most organochlorine contaminants was recorded from the early 1970s to the mid-1980s in spottail shiners (Suns et al. 1993), lake trout (Borgmann and Whittle 1991; Hesselberg and Gannon 1995), walleye (Hesselberg and Gannon 1995) and herring gulls (Pekarik and Weseloh 1998; Hebert et al. 1999a) followed by a leveling off of downward trends (for some compounds in some species) since then. However, the pattern of compounds found in each species varies according to its ecology (particularly trophic position), the physical-chemical properties of the compound determining its persistence, and the metabolic capacity of the species (Baumann and Whittle 1988; Norstrom 1988). The impact of metabolic capacity on contaminant patterns has been demonstrated for arctic marine species (Norstrom and Muir 1994), as well, and there is certainly evidence for differing metabolic capacities resulting in differences in patterns observed between marine mammals and seabirds (Kawano et al. 1988; Tanabe et al. 1988; Braune and Simon, submitted). A comparison of temporal trends for a number of organochlorine compounds in ringed seals, polar bears and three species of arctic seabirds showed that there were significant differences in the rates of change among species (Braune 2001). As Harding (1992) pointed out, "*There is no single magic set of ecosystem indicators applicable to all marine ecosystems.*"

2.1.2 HCHs: a case study

Hexachlorocyclohexanes (HCHs) constitute a pesticide introduced during the 1940s in a product known as technical HCH which was composed of five isomers (α, β, γ, δ, ε), only three of which (α, β, γ) are generally observed in biological samples, and only one of which (γ, later manufactured as a product called lindane) has insecticidal properties. The trend of HCHs found in the Arctic varies with compartment and species. High volatility of HCHs permits easy partitioning into the atmosphere and transportation via air currents to the Canadian Arctic where HCHs (mainly as α-HCH) are the most abundant of all organochlorine compounds found in atmospheric samples (Macdonald et al. 2000). At low temperatures, HCHs partition from air into water which favours deposition into northern oceans (Wania and Mackay 1993). The Canadian Basin of the Arctic Ocean contains HCH concentrations in its surface waters (mainly as α-HCH)

which are elevated by a factor of two or more compared with other areas of the Arctic Ocean or oceans to the south, and due to the permanent ice cover, volatilization from the surface waters of the Basin is suppressed (Macdonald et al. 2000). The relatively high concentrations of HCHs in waters of the Canadian Archipelago (Falconer et al. 1995) are best explained by the flow of surface waters from the Canadian Basin which reflects conditions of about a decade ago when atmospheric concentrations of HCHs were much greater (de March et al. 1998). Therefore, although HCH concentrations in air have decreased in recent decades (Bidleman et al. 1995a, b), corresponding decreases of concentrations in the marine ecosystem may be delayed. HCHs were formerly higher in the western Canadian Arctic than in the east (Norstrom et al. 1998), presumably as a result of their use in Asia. In polar bears, the HCH distribution in fat of male polar bears among five areas in 1990 was more uniform than it was in 1984, suggesting that Asian sources had decreased between 1984 and 1990, allowing steady state conditions to be more closely approached throughout the Canadian Arctic. There were significant downward trends in α-HCH in polar bears from some areas but no significant changes in β-HCH and ΣHCH. Concentrations of α- and γ-HCH in ringed seals from Holman Island in the western Canadian Arctic have remained unchanged since the late 1960s (Addison and Smith 1998) whereas concentrations of β-HCH have increased from 1975 to 1998 in seabirds from Prince Leopold Island while concentrations of α-HCH decreased or remained unchanged (Braune et al. 2001). Addison and Smith (1998) concluded that the lag time for atmospheric HCH trends to be reflected in the food web will be at least a decade as predicted by Wania and Mackay's (1999) half-life estimate of 11.5 years for α-HCH in the Arctic Ocean. Changes in HCH levels will, therefore, likely be reflected in marine biota, including seabird eggs, in future years. The importance of monitoring HCH isomers in various compartments/species has been demonstrated by Moisey et al. (2001a). They illustrated the changing proportions of the various HCH isomers through progressively higher trophic levels of an arctic marine ecosystem showing the shift in importance from α-HCH in air and water to β-HCH in upper trophic level organisms including seabirds. Similarly, Norstrom and Muir (1994) illustrated the differing magnitudes of importance of other groups of organocompounds (e.g. chlordanes, PCBs, DDTs) among the various compartments/species in an arctic marine ecosystem. The dangers of limiting monitoring activities to only one compartment or one species are clearly evident.

2.2 "Flagship" CWS Contaminant Monitoring Programs

2.2.1 Great Lakes Herring Gull Monitoring Program

The Great Lakes Herring Gull Monitoring Program (GLHGMP) has provided information concerning levels and effects of environmental contaminants in herring gulls since 1974 (Gilbertson 1974; Gilman et al. 1977; Weseloh et al. 1979; Struger et al. 1985; Bishop et al. 1992; Fox et al. 1998; Hebert et al. 1999a). This program is one of only a very few biological investigations in the world that has been undertaken into large-scale toxicological phenomena over a long period of time (Gilbertson 2001). Samples are collected annually from 15 locations: 2-3 colonies on each of the Great Lakes as well as colonies on the Detroit, Niagara, and St. Lawrence Rivers (Mineau et al. 1984; Hebert et al. 1999a). The program was initiated in response to observations of poor reproductive success in colonial waterbirds on the Great Lakes (Gilbertson 1974, 1975; Gilbertson and Hale 1974a, b). Initial studies examined the role of halogenated aromatic hydrocarbons (HAHs) in causing this reproductive dysfunction. By the late 1970s, reproductive success in herring gulls had improved greatly and emphasis was placed on developing more sensitive measures of subtle effects associated with HAH exposure to address the need for early warning indicators of ecosystem health. In an effort to achieve that goal, research has examined the utility of physiological, immune, and reproductive endpoints as indicators of exposure to environmental contaminants (see Fox et al. 1998; Fox 2001). More regular monitoring of effects related to contaminant exposure is recognized as an important monitoring priority on the Great Lakes (Environment Canada 2003).

A central component of the GLHGMP has been the analysis of eggs to elucidate geographic and temporal trends in Great Lakes contamination (Weseloh et al. 1990, 1994; Ewins et al. 1992; Pekarik and Weseloh 1998). Analysis of herring gull tissues led to the identification of HAHs (mirex, photomirex, polynuclear aromatic hydrocarbons, chlorobenzenes, dioxins) previously undetected in Great Lakes upper trophic level biota. Data collected as part of this program have improved our understanding of contaminant sources and fate in the Great Lakes and have provided us with a means to assess our progress in reducing contaminant inputs. Those data have been published in several atlases (Bishop et al. 1992; Pettit et al. 1994; Pekarik et al. 1998; Jermyn et al. 2002). As well, the Great Lakes herring gull data have been analyzed by non-CWS

staff (Smith 1995a, b, c, 2000; Stow et al. 1998). Their analysis of the data often presents a slightly different approach from that of CWS and is a useful external evaluation. The extensive nature of this dataset has allowed detailed examination of the factors that regulate contaminant levels in this species (Hebert 1998; Hebert et al. 2000). Most monitoring programs rely on less extensive datasets for the interpretation of environmental trends and could benefit from the lessons learned through the GLHGMP. Research has also identified other stressors, e.g. dietary deficiencies, that may affect the success of Great Lakes fish-eating bird populations (Hebert et al. 1999a). Ongoing monitoring of this species has provided new insights into the dynamic Great Lakes ecosystem.

2.2.2 Marine Seabird Egg Monitoring Programs

There are three programs monitoring contaminants in marine seabird eggs, one for each of Canada's marine environments: Atlantic, Pacific and Arctic. CWS has regularly monitored chemicals in seabird eggs on the Atlantic coast since 1968, and on the Pacific coast, since 1985 although some Pacific collections were made starting in 1970. Originally 5-10 eggs were collected for each species per colony and analyzed either individually or as a single pool. Starting in 1990, however, the sampling protocol was changed to collecting 15 eggs per species per colony and analyzing them as 5 pooled samples of 3 eggs each in order to reduce the variance and to increase the power to detect change (Elliott et al. 1992a) as recommended by Gilbertson et al. (1987).

On the Atlantic coast, eggs were collected every 4 years from two nesting colonies for each of three species. The three species chosen for the Atlantic coast monitoring program were the double-crested cormorant, an inshore feeder to detect contaminants in coastal run-off; the Leach's storm petrel (*Oceanodroma leucorhoa*), a pelagic surface feeder to detect contaminants from atmospheric fall-out; and the Atlantic puffin (*Fratercula arctica*), an offshore subsurface feeder. The contaminant data for the Atlantic seabird egg monitoring program have been presented in Noble and Elliott (1986), Pearce et al. (1989), Noble (1990) and Elliott et al. (1992a). Additionally, northern gannets (*Sula bassanus*) have been monitored on Bonaventure Island in the Gulf of St. Lawrence since 1968 (Elliott et al. 1988).

The Pacific program is patterned after the Atlantic program but collections are carried out every 4-5 years because collections span a period of two years due to logistical difficulties in reaching all of the colonies in one collection year. The species selected for the Pacific program are the double-crested cormorant, the pelagic cormorant (*Phalacrocorax pelagicus*), Leach's storm petrel and the rhinoceros auklet (*Cerorhinca monocerata*). The contaminant data for the Pacific seabird egg monitoring program have been presented in Noble and Elliott (1986), Elliott et al. (1989), Noble (1990), Elliott et al. (1992a) and Harris et al. (2003b). The naturally occurring, bioaccumulating halogenated dimethylbipyrroles (HDBPs) were first identified in Leach's storm petrel eggs from the Pacific (Tittlemier et al. 1999).

In the Arctic, eggs of three species of seabirds have been collected from Prince Leopold Island at irregular intervals since 1975. Since 1988, however, federal funding from the Northern Contaminants Program has enabled sampling to be carried out regularly every 5 years. The three species monitored in the Arctic are the thick-billed murre (*Uria lomvia*), the northern fulmar (*Fulmaris glacialis*) and the black-legged kittiwake (*Rissa tridactyla*). In 1993, the glaucous gull (*Larus hyperboreus*) and black guillemot (*Cepphus grylle*) were added as monitoring species to facilitate comparisons with Scandinavian monitoring programs. The contaminant data for the Arctic seabird egg monitoring program have been presented in Noble and Elliott (1986), Nettleship and Peakall (1987), Noble (1990), Elliott et al. (1992a) and Braune et al. (2001).

Superimposed on the regular contaminant monitoring programs are surveys which include a wider range of species and/or sampling locations. These surveys are carried out at intervals over the course of the monitoring programs.

2.2.3 Other CWS Contaminant Monitoring Projects

In addition to the "flagship" contaminant monitoring programs on Great Lakes herring gull eggs and coastal seabird eggs, there has been a number of other contaminant monitoring exercises undertaken or proposed. Monitoring of contaminants has been undertaken for reptiles and amphibians (Bishop and Gendron 1998); for great blue herons (*Ardea herodias*) in Quebec (Elliott et al. 1996; Champoux et al 2000; Champoux et al. 2002) and on the British Columbia

coast (Elliott et al. 2001; Harris et al. 2003a); for double-crested cormorants on the Great Lakes (Ryckman et al. 2000); for several raptor species from across Canada (Noble and Elliott 1990; Noble et al. 1993) as well as studies focussing on species such as peregrine falcons (*Falco peregrinus*) (Peakall et al. 1990), osprey from the Pacific Northwest and Great Lakes (Elliott et al. 1998; Ewins et al. 1999; Elliott et al. 2000) and sharp-shinned hawks (*Accipiter striatus*) from the Great Lakes (Elliott and Shutt 1993); and for polar bears in the Canadian Arctic (Norstrom et al. 1986; Braune et al. 1991; Norstrom et al. 1998; Norstrom 2001). As with the "flagship" programs, each of these additional programs arose to address a specific contaminants issue, choosing species and locations appropriate to the issue. For example, the monitoring of reptiles and amphibians was initiated in response to unexplained population declines coupled with lack of contaminants information for these species. Similarly, the monitoring of raptor and cormorant populations began in the 1960s in response to concern over declining populations of peregrine falcons affected by the use of DDT. Several species of raptors were monitored by CWS for various reasons over the years but those programs have, for the most part, been terminated. The more recent monitoring of sharp-shinned hawks was intended to address the issue of wintering versus breeding ground exposure to organochlorines to assess the suitability of this species for monitoring. The monitoring of great blue herons and ospreys in British Columbia was designed to examine contaminants related to pulp-mill discharges and in Quebec, great blue herons are monitored as a bioindicator of the health of the St. Lawrence River ecosystem. The monitoring of polar bears in the Canadian Arctic served much the same purpose as the monitoring of herring gulls in the Great Lakes, that is, the polar bear was chosen as a species at the top of the arctic marine food web which could be monitored for effects and could serve as a sentinel for human exposure of contaminants through wild foods. A number of new contaminants (e.g. TCPMe, TCPM, photoheptachlor, 4-hydroxy-heptachlorostyrene) as well as enantiomers of historical contaminants were identified as part of the polar bear monitoring program (Jarman et al. 1992; Zhu and Norstrom 1994; Zhu et al. 1995; Sandau et al. 2000; Wiberg et al. 2000) and many of the structures of the methylsulfone and hydroxy-PCB metabolites were identified for the first time in polar bears (Letcher et al. 1995; Letcher et al. 1998).

2.2.4 Funding and Logistical Support of "Flagship" CWS Contaminant Monitoring Programs

Successful monitoring programs and their associated activities require adequate and dedicated funding over the long term (Harding 1992; Fraser and Hodgson 1995) as well as institutional support at many levels of government (Fraser and Hodgson 1995).

Great Lakes Herring Gull Contaminant Monitoring: For the Great Lakes Herring Gull Program, Ontario Region staff makes most of the annual egg collections. Assistance has been provided by staff from CWS-NWRC (National Wildlife Research Centre), Brock University, McMaster University, Lakehead University, Wright State University (OH) and Winona State University (MN). Logistical support has been provided by the Technical Operations Division at the Canada Centre for Inland Waters. Ontario Region provides regular A-base and Great Lakes A-base funding to cover the costs of salaries, equipment such as boats, fieldwork, contractors, and makes a partial payment towards the costs of the contaminant analysis by CWS-NWRC.

Atlantic Seabird Contaminant Monitoring: Historically, sample collections were made every four years specifically for this program by CWS staff from Atlantic and Quebec Regions. Assistance with collections has also been provided by regional CWS seabird scientists, staff from the New Brunswick Museum and the Bowdoin College Scientific Station on Kent Island, and students from Memorial University of Newfoundland. The cost of chemical analyses was absorbed by CWS-NWRC.

Pacific Seabird Contaminant Monitoring: Pacific and Yukon Region of Environment Canada provides A-base funding to cover costs of the field work component of this program and the Canadian Coast Guard (DFO) has provided some logistical support. This program has also occasionally been able to take advantage of other seabird work being carried out at various colonies in order to facilitate sampling. The cost of chemical analyses was absorbed by CWS-NWRC.

Arctic Seabird Contaminant Monitoring: Historically, sample collections for this program were made opportunistically in conjunction with other studies being carried out on arctic seabird colonies. Logistical support has been contributed by the Polar Continental Shelf Project managed by Natural Resources Canada and the cost of chemical analyses of the samples was absorbed by CWS-NWRC. Since 1993, the Northern Contaminants Program (NCP) administrated by Indian and Northern Affairs Canada has fully funded CWS monitoring activities involving contaminants in arctic seabirds including retrospective studies.

3. Tools of the Trade

3.1 Specimen Banking

Specimen banking is now recognized as being an integral part of any systematic environmental monitoring program. The Canadian Wildlife Service maintains a Specimen Bank for wildlife samples with some holdings dating back to the 1960s. The banking of specimens has allowed scientists to carry out retrospective studies of newly identified environmental contaminants, determine when they appeared in a given ecosystem, determine if concentrations are increasing and if so, how rapidly. Retrospective studies are also carried out in order to obtain a standardized data set when chemical analytical methodology has changed over time (see Turle et al. 1988); to generate related datasets, such as stable isotope values in eggs, to aid in the interpretation of existing chemical data sets; or simply to analyze for contaminants not consistently monitored in the past. For example, archived samples have made possible retrospective analyses of mercury in the Great Lakes (Koster et al. 1996) and the Arctic (Braune et al. 2001), dioxins and furans (Hebert et al. 1994) and polybrominated diphenyl ethers (Norstrom et al. 2002) in the Great Lakes and the Arctic (CWS, unpubl. data), and organochlorines in northern gannets from eastern Canada (Elliott et al. 1988).

3.2 Quality Assurance/Quality Control

All monitoring programs should have written protocols that describe in detail the work to be done. To achieve this, we have quality assurance (QA) and quality control (QC). QA has been described as a management tool that addresses all aspects of a program and establishes an operational framework to help ensure all of the factors affecting that program are considered or, putting it another way, all those planned or systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements of quality (Shampine 1993). QC is a "worker" tool which represents the day-to-day actions involved in collecting data or the operational techniques and activities used to fulfill the requirements of quality (Shampine 1993). Together, QA/QC ensure data quality, consistency and comparability, as well as availability and accessibility. The implementation of QA/QC programs must extend from the field sampling procedures and laboratory standard methods to both inter- and intra-laboratory tests and the development and maintenance of databases (Fraser and Hodgson 1995).

Turle et al. (1988) demonstrated how changes in analytical methods over time, if not properly documented, could lead to erroneous interpretations of monitoring data by scientists. Using CWS Contaminant Monitoring Programs as an example, Turle et al. (1988) showed how appropriate uses of specimen banking, reference materials and rigorous quality assurance procedures could prevent or minimize such errors. To this end, CWS has developed its own set of in-house reference materials (Turle et al. 1988; Wakeford and Turle 1997) as well as detailed protocols for sample processing and analysis (e.g. Neugebauer et al. 2000; Simon and Wakeford 2000; Won et al. 2000). CWS Laboratories have participated in a number of inter-laboratory comparison studies. In 1995, CWS Laboratory Services, NWRC, was granted accreditation by the Standards Council of Canada (SCC), in co-operation with the Canadian Association for Environmental Analytical Laboratories (CAEAL). Contractual arrangements set up with private sector laboratories to perform work for NWRC (in excess of the Laboratory's capacity) specify all the requirements for QA/QC which the contractor must observe. According to the CWS Quality Manual (Version 8.0, July 2001), a major criterion for selection of private sector laboratories is that they, too, have been accredited through the CAEAL/SCC process or equivalent. Records of performance of contracted work are kept on file in the Quality Assurance officer's office.

3.3 Data Management

The objective of good data management is to ensure that the data management process incorporates adequate procedures for the security, recording, calculation, validation, authorization, transmittal, storage and disposal of all test data and related records (CWS Quality Manual, Version 8.0, July 2001). To this end, CWS maintains several logs of information on projects and specimens. These include laboratory workbooks which contain details of specimen dissection and all pertinent information on samples which are being processed. Logs of injections on gas chromatograph (GC) and GC/mass spectrometer instruments are maintained to cross reference with the laboratory workbooks. The logs list every sample extract injected into instruments including the name of the computer file with the chromatographic raw data. All electronically gathered chromatographic and mass spectrometric data are stored on magnetic tapes or optical disks in addition to hard copies. Reports of analytical work are made to Project Officers and copies of all reports (both electronic and hardcopy) are maintained in locked cabinets. The reported analytical results are appended to the sample files in the NWRC Laboratory Information Management System (LIMS) using routines developed by the LIMS Database Manager. Analytical test results, where appropriate, are compared with expected values, ranges, or relationships with other wildlife toxicology data. Data calculations and transcriptions are independently checked and verified, and appropriate data validation records are kept. At present, the LIMS is used primarily to track the Tissue Preparation and Specimen Banking unit workload. All analytical data are stored in the LIMS files and these files are considered the final archival record of information. The security of this system is the responsibility of the Data Base Manager. It has been determined that, under no circumstances, except as dictated by a Court of Law, shall records be removed from the laboratory, and requirements for ensuring client confidentiality shall be observed when making records available.

4. Statistical Power of Contaminant Monitoring Programs

In this era of fiscal restraint, the utility of long-term monitoring programs in evaluating temporal trends in persistent organic pollutants (POPs) is often questioned. One aspect of this debate is the issue of whether it is necessary to conduct annual monitoring, or whether less frequent sampling would be adequate and more cost-effective. A frequent problem encountered when attempting to elucidate temporal trends in biomonitoring data is that the "noise" associated with concentration measurements may obscure the "signal" associated with trends. The probability that a monitoring program will detect a temporal trend in concentrations when a trend is occurring, in spite of the "noise" in the data, represents its statistical power. Implications of ignoring power include collection of insufficient data to make reliable inferences about temporal trends and/or collection of extraneous data. The probability or power of detecting changes in contaminant levels with time depends both on the pattern and magnitude of those changes (Nicholson and Fryer 1992). For example, Nicholson and Fryer (1992) analyzed a 10-year program monitoring mercury residue levels annually in fish and found that there was a 90% chance of detecting a 20% increase if that increase occurred as a single increment in the middle of a 10-year period. However, if that increase occurred gradually over the 10 years, there would only be a 50% chance of observing a significant change, and alternatively, for the power to remain at 90%, the size of the gradual increase would need to be just over 30% in 10 years. In reality, however, the pattern of between-year variation will not necessarily follow standardized scenarios. Bignert et al. (1998) concluded that continuous, long-term, annual, monitoring studies on contaminants based on biota samples provided a very useful tool for describing environmental processes, providing they take between-year variations into consideration. Long time series show random between-year variations which are not part of a trend clearly demonstrating the risks in using small, scattered sets of data on occasionally collected samples for interpreting environmental issues (Bignert et al. 1993; Bignert et al. 1994; Olsson 1995; Bignert et al. 1998).

As part of the Arctic Monitoring and Assessment Program's (AMAP) Phase II assessment of contaminant monitoring programs, Anders Bignert (Swedish Museum of Natural History) carried out power analyses using CWS data for mercury residue levels in eggs of thick-billed murres

from Prince Leopold Island in the Canadian High Arctic collected opportunistically 7 times during a 24-year time period (1975-1998). The results show that the number of sampling years required in order to detect an annual change of 5% with a power of 80% at a significance level of 5% is 11 years (ICES 2002). (Note: although the 7 collections were made over a period of 24 years, the power analysis treats the data as annual collections) This means that sampling continued at a frequency of once every 5 years, a sampling pattern established since 1988, would take the monitoring program to 2018 to meet the requirements for detecting statistical change.

4.1 Case study - Great Lakes Herring Gull Monitoring Program

The various CWS monitoring programs have employed different strategies in attempting to assess temporal change in contaminant bioavailability. For example, the Canadian Wildlife Service's Great Lakes Herring Gull Monitoring Program collects egg data on an annual basis (Hebert et al. 1999a). Other marine seabird egg monitoring programs in Canada collect data less frequently, with periods of 4-5 years between collections (Elliott et al. 1989; Pearce et al. 1989; Noble 1990; Braune et al. 2001). These strategies generally reflect differences in regional priorities and resources available for these programs. There is no doubt that all of these monitoring programs have supplied useful data regarding spatial differences and temporal trends in contaminant levels. However, in an effort to understand how differences in sampling regimes affect our ability to elucidate temporal changes in levels of POPs in the environment, the effect of sampling frequency on the detection of statistically significant temporal trends in egg contaminant levels was examined by Hebert and Weseloh (in press) using data from the Great Lakes Herring Gull Monitoring Program. Five scenarios were employed to examine the effect of different sampling regimes on the interpretation of these temporal monitoring data: Scenario 1: collections every year; Scenario 2: collections every second year; Scenario 3: collections every third year; Scenario 4: collections every fourth year; and Scenario 5: collections every fifth year. Analysis of data collected annually (Scenario 1) from 1980 to 2001 indicated that 33 of 35 colony-compound regressions (94%) showed a statistically significant temporal decline (Table 1). When data collected every second year were used, 80% of the regressions showed a statistically significant decline (Table 1). Analysis of data under Scenarios 3, 4, and 5 indicated that 100%, 54%, and 63% of the regressions showed a significant decline through time (Table 1).

In other words, decreased identification of statistically significant trends was apparent in the sampling regimes where samples were collected less frequently. Results of a power analysis indicated that less regular sampling regimes (i.e. Scenarios 2-5) were somewhat deficient in terms of their ability to detect temporal trends of the magnitude that are currently observed as part of the GLHGMP (Figure 1). When statistically significant declines were observed, sampling at two and four year intervals resulted in the trend being identified later than with annual monitoring. The fact that under Scenario 3 all of the compounds were found to be declining indicates that erroneous conclusions may be drawn when utilizing less robust data sets to infer temporal declines.

Table 1. A summary of the results of the regression analyses determining whether statistically significant declines in contaminant levels could be detected under the different sampling regimes (Scenarios 1-5) for the entire 1980-2001 period of the Great Lakes Herring Gull Monitoring Program. Shaded cells indicate that a statistically significant decline was detected. Unshaded cells indicate that no significant trend was observed. Results are shown for each Great Lakes colony (S - Snake Island, M - Middle Island, D - Double Island, A - Agawa Rocks, G - Gull Island). Taken from Hebert and Weseloh (in press).

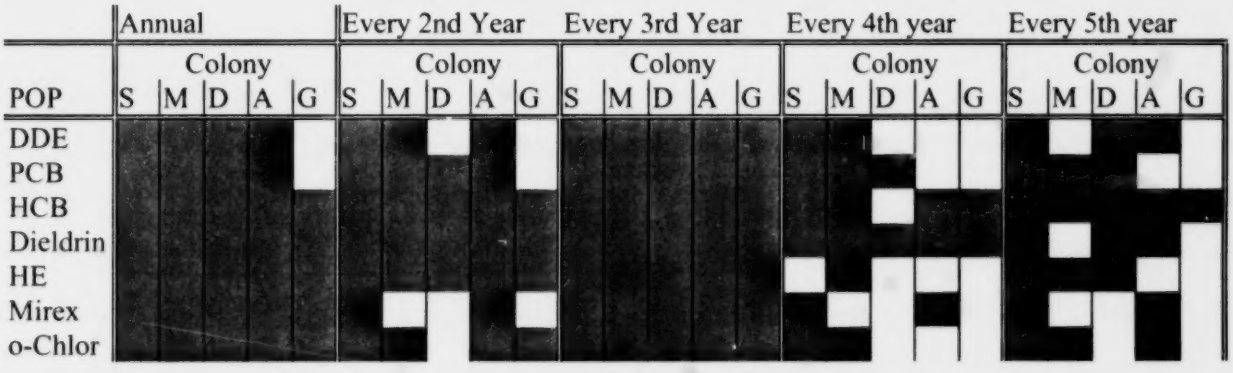
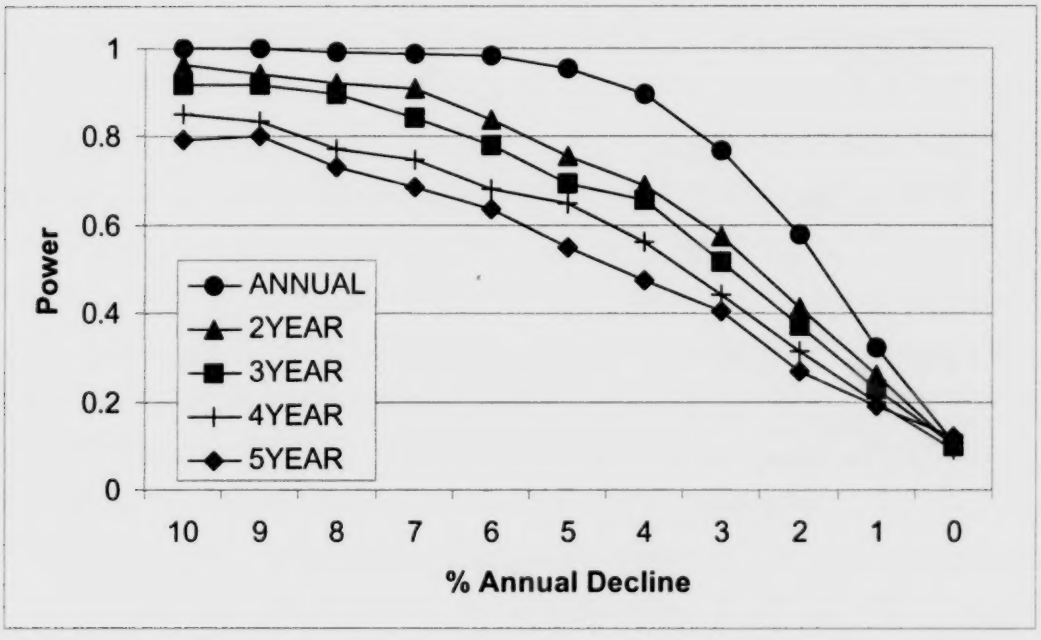


Figure 1. Power to detect a temporal decline in egg contaminant levels under five sampling regimes with different sampling frequencies (Scenario 1 – annually, Scenario 2 – every 2nd year, Scenario 3 – every 3rd year, Scenario 4 – every 4th year, Scenario 5 – every 5th year). Magnitude of temporal declines included in the analysis ranged from 0-10% per year. Mean rate of decline, based upon GLHGMP data, is 3-4% per year. Taken from Hebert and Weseloh (in press).



5. Balancing Act

The design of monitoring programs must balance costs and data quality. Long-term contaminant monitoring programs have demonstrated their usefulness in evaluating temporal declines in levels of environmental contaminants (Olsson and Reutergardh 1986; De Vault et al. 1996; Pekarik and Weseloh 1998; Braune et al. 2001, Lindell et al. 2001). They have also provided insights into other areas of research that were unforeseen when the programs were first established (Hebert et al. 1999b; Chen et al. 2001). Periodically, however, these programs are confronted with elimination or reduction as a result of financial constraints. The results presented in Section 4.1 indicate that decreasing the frequency of sampling may have important ramifications for the elucidation of contaminant temporal trends. Programs that collect samples at widely spaced intervals will take longer to detect significant changes in levels of contaminants

in the environment, or worse, may not detect the change at all. These problems stem, in part, from the decreased statistical power associated with analyses restricted to fewer data points. As the number of data points diminishes, each data point becomes more influential in affecting the overall trend and aberrant data points can have a great affect on trend detection. Scientists and managers should consider the possibility that the collection of data at widely separated intervals may not provide them with sufficiently powerful data to detect current and future change, and that sampling strategies need to be compatible with the ultimate aim of the program (see Bignert et al. 1993; Parr et al. 2002). Another aspect to consider is that statistical significance and environmental significance are often inconsistent concepts (McBride et al. 1993), with statistical significance largely determined by sample size (Stow et al. 1998). However, trend data which are not statistically significant, are generally disregarded (Stow et al. 1998) and so one is left with the necessity of establishing statistical significance in order for decision makers to accept the data as "important" and act upon them (Ter Keurs and Meelis 1986).

The analysis presented here provides evidence that more frequent sampling does provide tangible benefits from a monitoring perspective. However, do the differences identified here merit the additional resources that are required to monitor on an annual basis? The answer to that question is as much driven by priorities as science and will reflect the balance between the cost of the program and collecting data in a manner that allows us to answer critical questions. For example, *does it matter if the detection of a statistically significant trend is delayed by a matter of years?* Perhaps not, however, there are situations where timely information is of the essence. For example, in the Great Lakes, ongoing Remedial Action Plans are addressing contaminant issues at many Areas of Concern. Managers responsible for this work need to know if remedial actions are effective. Therefore, it is critical to be able to assess temporal changes in the bioavailability of environmental contaminants in a timely manner. Lack of this information could lead to the implementation of more costly remediation strategies that might, in fact, not be necessary. Therefore, we would suggest that delays in identifying significant temporal trends could have adverse consequences regarding our ability to manage the risk posed by environmental contaminants.

Does it matter whether a trend is ever detected? In most cases, the answer to this would be a resounding "yes". Results of the analysis presented in Section 4.1 indicated that less frequent sampling regimes could impede our ability to deduce a temporal change in contaminant bioavailability. It should be kept in mind that the results shown in Table 1 are based upon the analysis of data collected from the Great Lakes over a reasonably long period (21 years). If data were only available from a shorter period, differences among sampling regimes would have been greater. For example, when only the first ten years of data (1980-1990) were used in an identical analysis, only 29% of the contaminant-time regressions were significant for the biennial sampling regime, whereas, 63% of the regressions using annual data showed a significant decline. This is important because it emphasizes that programs of shorter duration, sampled less frequently, will be less robust in terms of providing the data necessary to detect significant temporal trends.

Another issue that also needs to be considered is whether the assessment of current trends might be less critical than in the past because levels are so much lower now. This point is really only germane if there is high confidence that POPs are no longer having detrimental effects on wildlife and, by extension, humans. Current concerns regarding the possible endocrine-disrupting effects of POPs do not support this (see National Institute of Environmental Health Sciences 2001). Therefore, maintaining and improving our ability to detect changes in the bioavailability of these compounds remains an important goal. In addition, not all persistent contaminants have exhibited temporal declines. In fact, levels of compounds such as mercury in the Arctic (Braune et al. 2001) and polybrominated diphenyl ethers in the Great Lakes and elsewhere (Moisey et al. 2001b; Alaee et al. 2002; Norstrom et al. 2002) have shown increases in wildlife and human tissues and continued monitoring will be necessary to evaluate the effect of control measures on reducing inputs of these compounds into the environment.

6. Assessment of Current CWS Contaminant Monitoring Programs

The CWS Contaminant Monitoring Program Assessment (CCMPA) was initiated in 1999. The objective was to assess CWS contaminant monitoring programs in the context of other monitoring programs as well as current contaminant issues, with respect to:

- Gaps and redundancies with other contaminant monitoring programs
- Relevance to current contaminant issues
- Relation to ecological/population monitoring programs

6.1 Creating the tools

The first phase of the assessment involved the creation of a searchable database (Appendix 1) containing information mainly on Canadian and Canadian-U.S. bilateral programs monitoring contaminants in biota. The database (in Access 2 format) contains detailed information on program descriptions, monitoring locations, and publications resulting from each program entered. The working definition of "monitoring" chosen for selection of monitoring programs required programs to have at least three temporal data points for a given sample population. Tables A1-1 to A1-4 in Appendix 1 provide summary statistics for the contents of the database. Tables A1-1 and A1-2 summarize the number of monitoring programs and monitoring sites identified as "ongoing" or "completed" in Canada (Table A1-2) as well as internationally (Table A1-1). Tables A1-3 and A1-4 show the breakdown of monitoring programs by CWS region and by contaminant type, respectively. A list of the Canadian contaminant monitoring programs contained in the database appears in Appendix 2 (Tables A2-1 to A2-4).

The second phase of the assessment involved the development of a "user friendly" custom graphical interface which uses Visual Basic programming to allow mapping of the database using ArcView 3.2 Geographic Information System (GIS) software. A brief overview of the mapping program is presented in Appendix 3. Interface with the GIS package allows creation of maps of Canadian contaminant monitoring programs based on selection of any combination of:

- *taxa* - birds, mammals, fish, etc.
- *tissue type* - egg, muscle, liver, etc.
- *contaminant type* - organochlorines, metals, radionuclides
- *specific contaminants* - PCBs, DDT, dioxins/furans, mercury
- *program status* - completed or ongoing
- *responsible agency* - CWS, DOE (incl. CWS), DFO, Provincial/Territorial, academic

These maps may be superimposed on geographical maps showing rivers, lakes, major cities, political boundaries, ecozones, etc., as desired. Figures 2 to 17 were generated using this mapping program.

The complete database and associated mapping program as well as detailed instructions for installation procedures and basic operation of the program are contained on the CD in the back pocket of this report.

6.2 Relevance of CWS Contaminant Monitoring Programs

One of the fundamental questions is: What kind of monitoring program(s) do we need?

- a targeted chemicals monitoring program?
- a contaminant effects program?
- a species/ecosystem health monitoring program?

It can be argued that the current CWS contaminant monitoring programs should be and are all of the above. It is the need for monitoring of contaminant stressors which acted as the catalyst for most CWS monitoring activities. As already described, CWS monitoring programs evolved in the late 1960s and early 1970s in response to evidence of widespread avian mortality, reproductive failure and other damage attributed to chemicals in certain contaminated systems such as the Great Lakes. The search for a cause of the observed effects lead to the monitoring of a variety of targeted chemicals. As a result, we now have a number of long-term data sets on a variety of chemical stressors as well as archived samples available for retrospective surveys. Historically, CWS has monitored the trends of compounds such as PCBs and DDE along with a suite of other organochlorine compounds including chlordanes, chlorobenzenes, dieldrin and mirex. The CWS Specimen Bank has allowed us to construct retrospective trends targeting dioxins and emerging contaminants of interest such as polybrominated diphenyl ethers (PBDEs) and perfluorinated compounds (e.g. PFOS) as well as historical contaminants of concern such as mercury which were never regularly monitored by CWS. We have the means to elucidate contaminant trends, past and present, in all of the major marine/aquatic ecosystems in Canada: the Atlantic, the Pacific, the Arctic, the Great Lakes and St. Lawrence (see Figure 8). The monitoring of contaminant stressors without determining chemical specificity has also advanced

with the development of new methods to detect biochemical endpoints (e.g. vitellogenin, acetylcholinesterase) that can indicate exposure to a group of chemicals such as endocrine disrupting compounds (EDCs). The monitoring of effects or endpoints becomes particularly important when dealing with non-persistent organic pollutants. The monitoring of specific chemicals as well as effects are integral components for monitoring species/ecosystem health. This type of baseline information gives us insights into ecosystem change and provides guidance with respect to other venues of study which should be pursued; e.g. changes in food availability, human impacts, habitat change, climate change, disease, effects of exotic species. Using contaminants as tracers of ecological processes provides one means of improving our ability to detect ecosystem change, particularly with respect to foodweb structure (see Hebert et al. 2000).

Given the continuing emergence of new chemicals to investigate (e.g. PBDEs, PFOS, pharmaceuticals) and the continuing interest in trends of historical POPs, CWS needs to have the capacity to evaluate how global release patterns of chemicals may affect wildlife exposure in Canada. For example, it is the monitoring of the historical POPs which has driven and continues to drive much of the remedial action taken in the Great Lakes. The capacity to conduct retrospective studies has enabled CWS to provide evidence for increasing trends of PBDEs in the Great Lakes (Norstrom et al. 2002) and the Arctic (Braune 2001; CWS, unpubl. data) as well as demonstrating increasing trends of mercury in the arctic marine environment (Braune et al. 2001) when trends further south have indicated declines (Koster et al. 1996). Numerous primary publications and reports have been generated as a result of the herring gull and seabird egg monitoring programs (Table 2). There are a total of 679 publications listed in the database, and 471 are associated with Canadian monitoring programs. Of those, 318 are related to Canadian contaminant projects and 174 of those are affiliated with CWS programs. As well, the programs have provided samples and information used in research studies which were developed as a result of the monitoring programs. As long as chemicals continue to be released into the environment, CWS needs to continue monitoring both chemical and effects trends in order to be prepared to address wildlife health issues in the context of chemical contaminants.

Table 2. The total number* of published scientific articles and citations associated with "Flagship" CWS contaminant monitoring programs.

Year	Total Number	Pacific - CA026 1971 - present = 30 years	Great Lakes - CA001 1972 - present = 29 years	Atlantic - CA053 1968 - present = 33 years	Arctic - CA012 1975 - present = 26 years
1970 - 1975	Articles		3		
	Citations		76		
1976 - 1980	Articles		11	1	
	Citations		365	31	
1981 - 1985	Articles		13		
	Citations		347		
1986 - 1990	Articles	3	17	2	1
	Citations	57	512	56	12
1991 - 1995	Articles	1	14	1	
	Citations	6	233	47	
1996 - 2001	Articles	1	15		1
	Citations	0	103		0
All Years	Articles	5	73	4	2
	Citations	63	1636	134	12
Average Number of Citations / Article		12.6	22.41	33.5	6
Average Number of Citations / Article / Year		0.42	0.77	1.02	0.23

* up to November 2001

We conclude that CWS should continue its contaminant monitoring programs and that the monitoring of targeted chemical residues, contaminant effects and species/ecosystem health are all necessary to provide an integrated program directed at understanding the role of contaminants with respect to wildlife and ecosystem health.

6.2.1 Assessment of contaminant monitoring programs

By comparing the total number of programs with the sum of the "contaminant" and "ecological" programs in Table A1-2, one can see that there are two "ongoing" programs and one "completed" program which served both the contaminant and ecological communities. Of the two ongoing programs, one is conducted by DFO and the other by CWS. One of the programs (CA-046; see

Appendix 2 for listing of programs) which combine both contaminant and ecological components is the Experimental Lakes Area (ELA) Project initiated in 1969 by DFO in northwestern Ontario. The program is comprised of a multidisciplinary collection of databases including biological (zooplankton, phytoplankton, benthos, fish), chemical, physical, hydrological and meteorological information on pristine and manipulated lakes, streams and watersheds in the area. The second ongoing program (CA-016) records the population, productivity and organochlorine contaminant trends in a northern gannet colony on Bonaventure Island off the Gaspé Peninsula of Québec in the Gulf of St. Lawrence from 1967 to 1984. The contaminants-monitoring part of the program was terminated for a period of time in the 1980s but the contaminants component has since been revived. The completed program (CA-054) looked at the population and productivity of cormorants on the Great Lakes in relation to levels of organochlorine contaminants from 1969 to 1975. The two CWS programs are good examples of collaborative work between population and contaminants researchers maximizing use of their resources and contributing to a better understanding of the overall health of the populations under study. There are, in fact, a number of additional CWS programs, both ongoing and completed, which carried out both contaminant and ecological monitoring on the same population(s) at the same site(s) but they were either listed in the database under separate program titles (e.g. CA-012 and CA-024) and/or one of the components (either contaminants or ecological monitoring) was terminated while monitoring of the other component continued (e.g. CA-103 and CA-104). More often than not, population monitoring was initiated first and contaminants monitoring was added at some point under a different program title.

If one compares maps showing the geographical distribution of monitoring sites for ongoing Canadian contaminant monitoring programs (Figure 2) and ongoing Canadian ecological monitoring programs (Figure 14), it is clear that much of the ecological monitoring focuses on birds whereas the contaminants monitoring focuses on fish with about half as many programs each targeting birds, mammals, and mixed and other taxa. Monitoring of contaminants in fish is carried out almost uniformly nation-wide (use of icons to describe polygons creates the illusion of fewer sites than are actually present; see Appendix 3 for explanation) whereas monitoring of contaminants in mammals is centred in the north (Figure 2). A comparison of ongoing avian

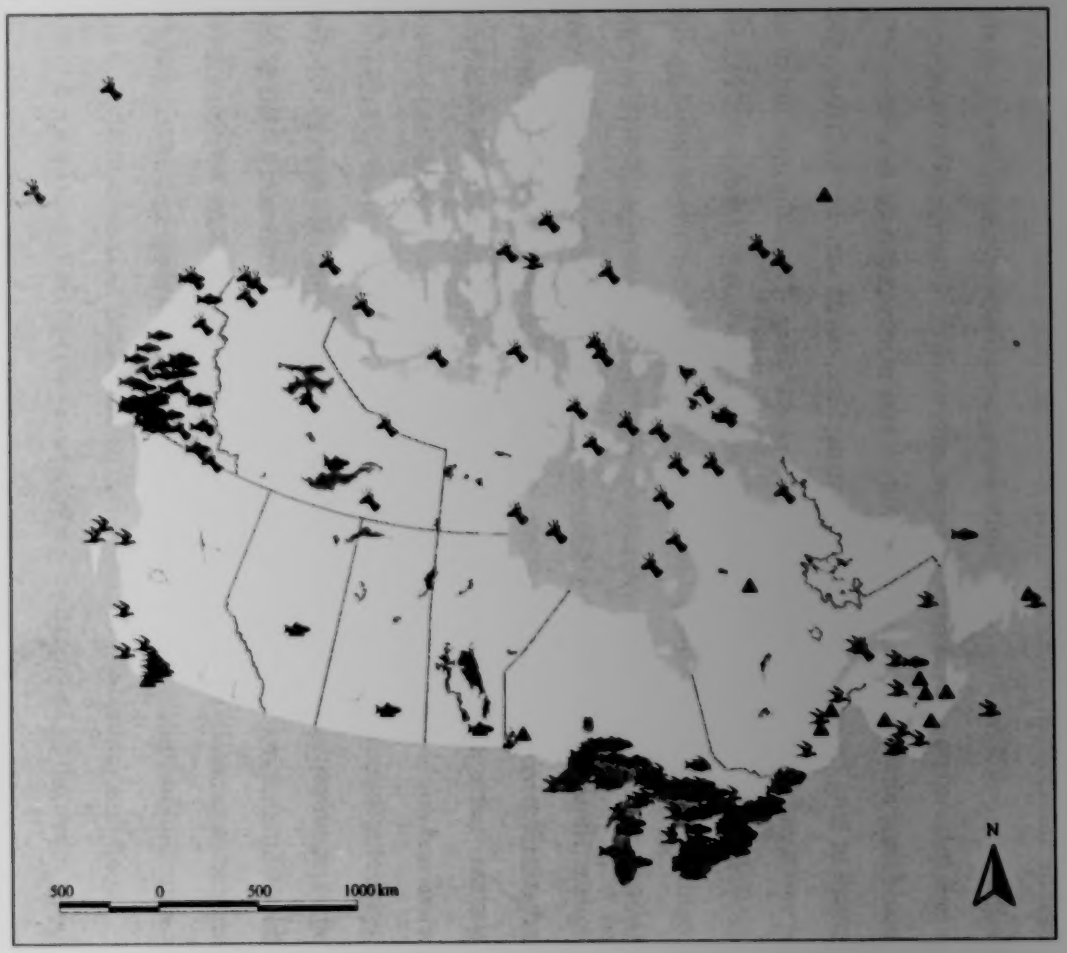
monitoring sites indicates that contaminants monitoring (Figure 8; all sites are part of CWS programs) focuses on the Great Lakes - St. Lawrence corridor as well as the Atlantic, Pacific and Arctic coasts. Figure 16 indicates that avian population monitoring goes on much more broadly nation-wide providing ample opportunity for possible collaboration if expansion of contaminant monitoring of avian populations were warranted. There are 26 ongoing programs identified which carry out avian population monitoring (Figure 16) contrasted with only 9 ongoing avian contaminant monitoring programs (Figure 8). Of the 13 completed Canadian avian contaminant monitoring programs (Figure 9), the majority dealt with raptors (Appendix 2). A comparison of Figures 5 and 7, and Figures 4 and 6, shows that a greater proportion of the monitoring effort has been, and still is, directed towards organic compounds rather than mercury and other metals. This holds true even if we look only at avian contaminant monitoring programs (Figures 10-13). It should be noted that retrospective study of mercury in Pacific seabird eggs does not appear on Figure 10 because mercury has not yet been formally included in the regular analytical protocol for that program.

It is sometimes questioned why more than one taxon should be monitored in a given ecosystem. This apparent duplication of effort is most evident for fish and birds in the Great Lakes, and marine mammals and birds in the Arctic (Figure 2). Much (although not all) of the monitoring of fish and marine mammals is driven by the need to assess the risk of contaminants to human consumers of those organisms. In contrast, the avian contaminant monitoring programs were initiated to investigate the state of wildlife health, and species and monitoring sites were selected accordingly. In those areas where multiple taxa are monitored for contaminants, reduction of the monitoring effort to one taxa or one species would severely compromise our understanding of the behaviour of the various contaminants in the ecosystem because of differing metabolic capacities among taxa and species, as discussed in Section 2.1.1, as well as their occupation of different levels in the food web. One must remember that there are two types of monitoring to be addressed: one which monitors the increases/decreases in contaminant levels, and the other which monitors ecosystem health. As demonstrated in Section 2.1.2, a contaminant trend demonstrated in one compartment of the ecosystem may not be indicative of the trends in other compartments. Further, limitation of monitoring to one taxa or species would severely

compromise available information on ecosystem/population health. In its worst manifestation, limitation of monitoring to a single species/taxa could lead to poor policy choices which could ultimately prove detrimental to some wildlife populations.

In addition to illustrating those areas where multiple species are monitored, Figures 2 and 8 also point out areas in which no contaminants monitoring appears to be in place, particularly for avian species (Figure 8). Again, this highlights the differences in objectives among the ongoing monitoring programs. The national coverage of the fish monitoring programs and the broad northern coverage of those programs monitoring contaminants in marine mammals satisfy the demand for information to assess the risk to human consumers. The distribution of the avian contaminant monitoring sites centres on those aquatic environments receiving contaminant loads from industrial/urban areas. The exception would seem to be the arctic monitoring site at Prince Leopold Island although it is now clear that no area is immune to the deposition of contaminants as a result of long-range transport via the atmosphere, ocean currents and rivers. When one looks at the vast areas devoid of any avian monitoring activities, it begs the question of whether or not there should be more monitoring sites added across the country. If the objective of monitoring is to provide ongoing data for as many species in as many areas of the country as possible in order to detect any contaminant problem that may arise, then the coverage of CWS monitoring sites is inadequate. However, the ongoing contaminants monitoring programs are being carried out in areas that have been identified as being at the greatest risk from exposure to persistent pollutants. Other areas such as agricultural lands may warrant more attention with respect to the effects of pesticides and nutrients on environmental quality. It has been suggested that, given the costs, contaminant monitoring programs should only be initiated in new areas as a result of investigative or research efforts which identify specific threats. This strategy, of course, reduces the value of monitoring as an early warning mechanism. However, if we were to accept that the coverage of current CWS contaminant monitoring activities need not be expanded in order to address currently-identified areas of concern, could existing programs be improved?

Figure 2. Ongoing Canadian contaminant programs - monitoring sites.

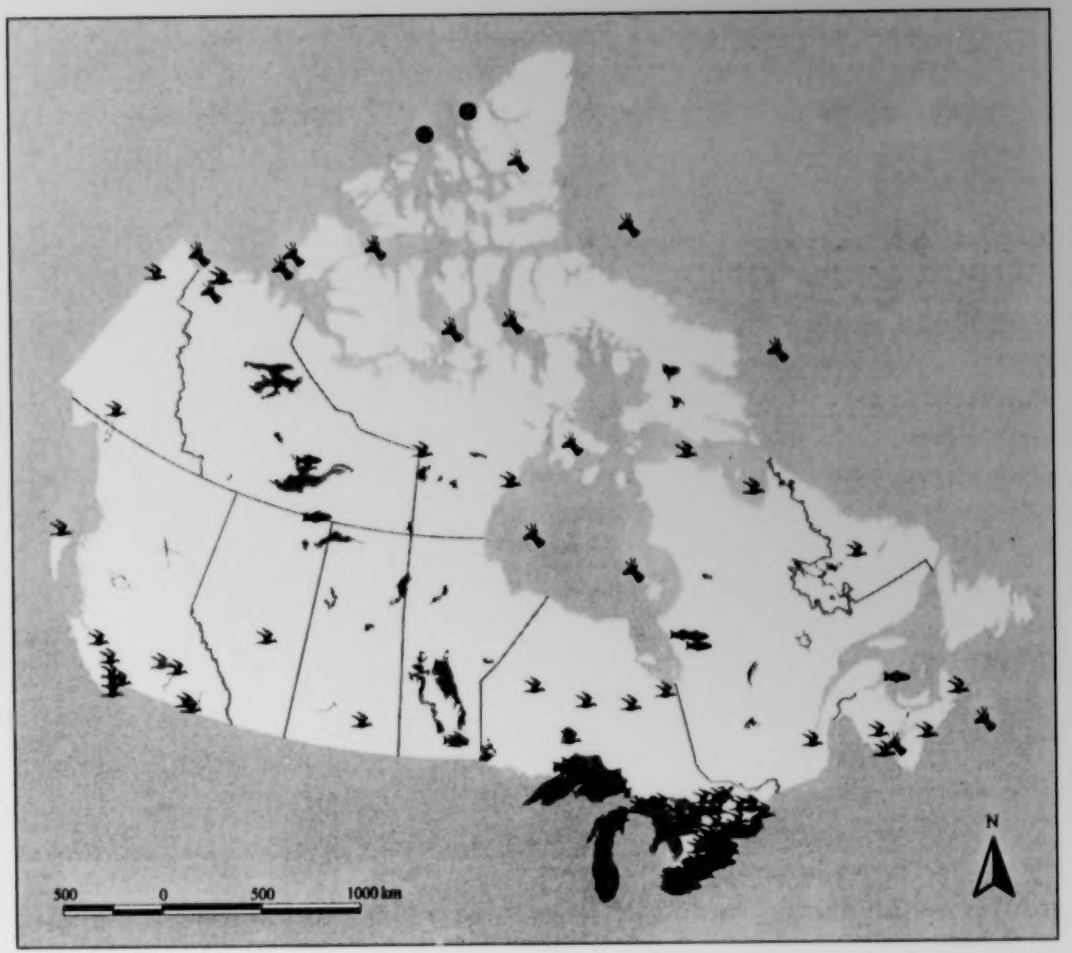


Taxa

- Birds
- Fish
- Mammals
- Herpetofauna
- Other
- Mixed

Taxa	Number of Programs	Number of Monitoring Sites
Birds	9	91
Fish	13	241
Mammals	7	61
Herpetofauna	0	0
Other	6	18
Mixed	8	23
All Taxa	30	386

Figure 3. Completed Canadian contaminant programs - monitoring sites

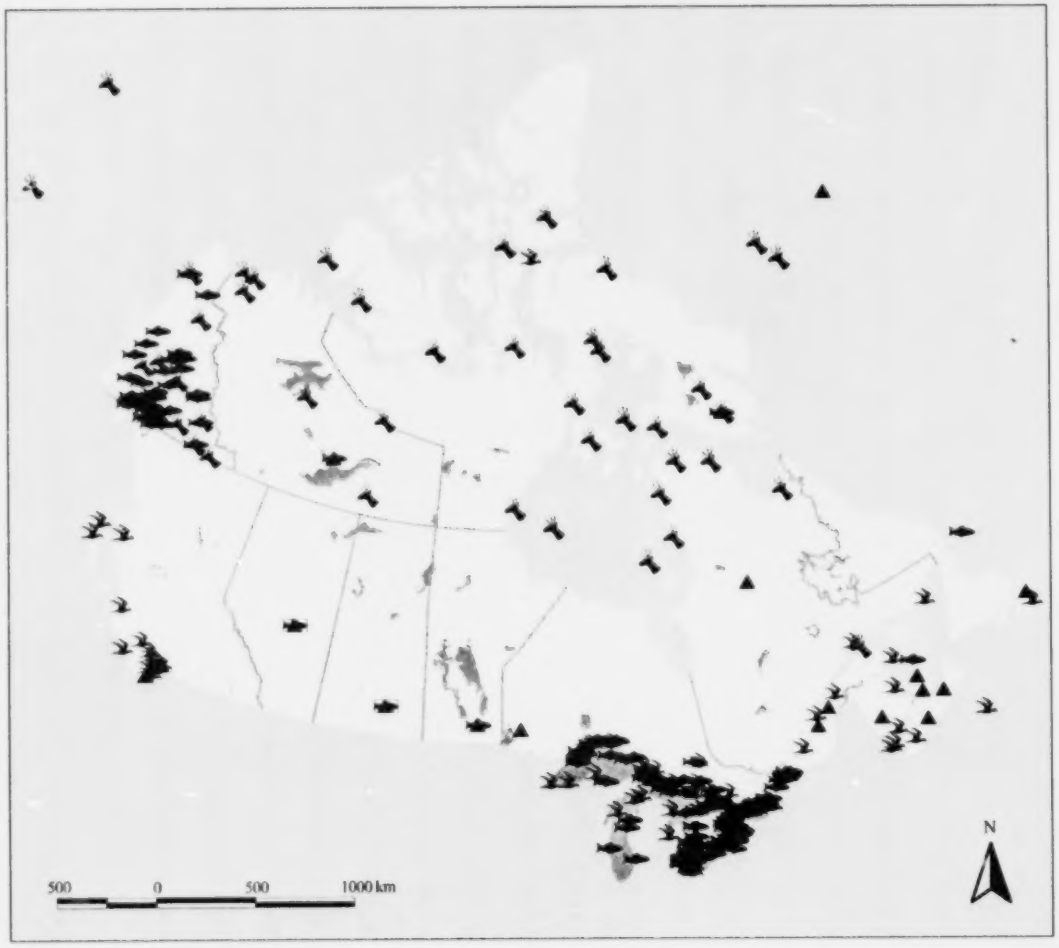


Taxa

- Birds
- Fish
- Mammals
- Herpetofauna
- Other
- Mixed

Taxa	Number of Programs	Number of Monitoring Sites
Birds	13	109
Fish	6	38
Mammals	5	15
Herpetofauna	1	6
Other	1	2
Mixed	0	0
All Taxa	26	170

Figure 2. Ongoing Canadian contaminant programs - monitoring sites.



Taxa

- Birds
- Fish
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- Mixed

Taxa	Number of Programs	Number of Monitoring Sites
Birds	9	91
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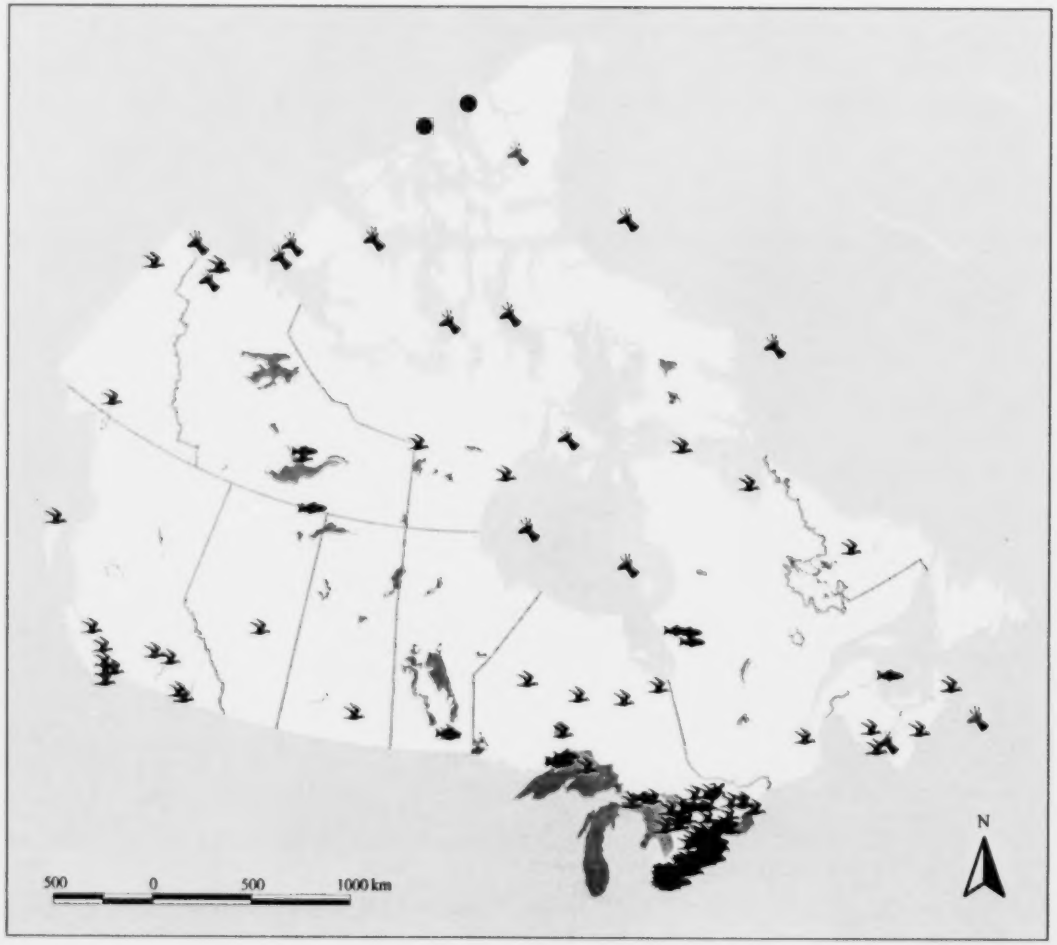
Mixed	8	23
All Taxa	30	386

Figure 3. Completed Canadian contaminant programs - monitoring sites

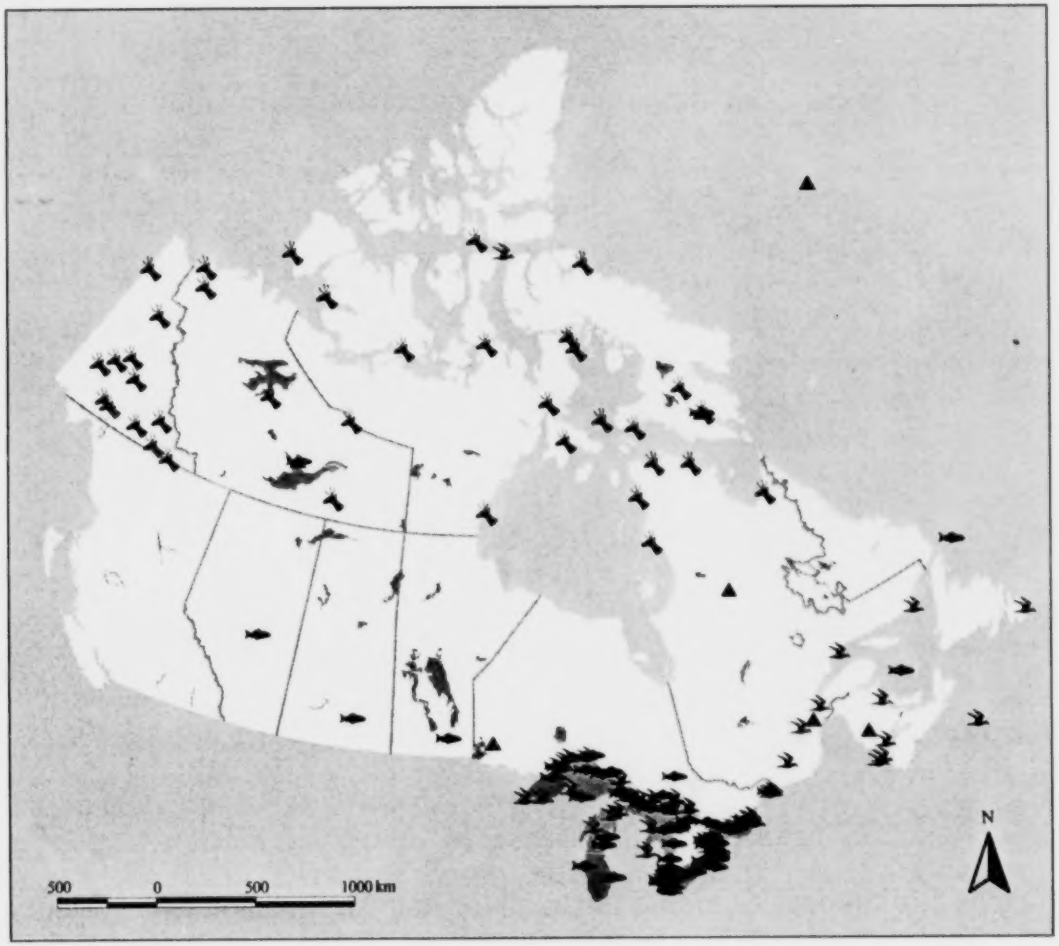


Taxa

- Birds
- Fish
- Mammals
- Herpetofauna
- Other
- Mixed

Taxa	Number of Programs	Number of Monitoring Sites
Birds	13	109
Fish	6	38
Mammals	5	15
Herpetofauna	1	6
Other	1	2
Mixed	0	0
All Taxa	26	170

Figure 4. Ongoing Canadian contaminant programs - sites monitored for mercury.

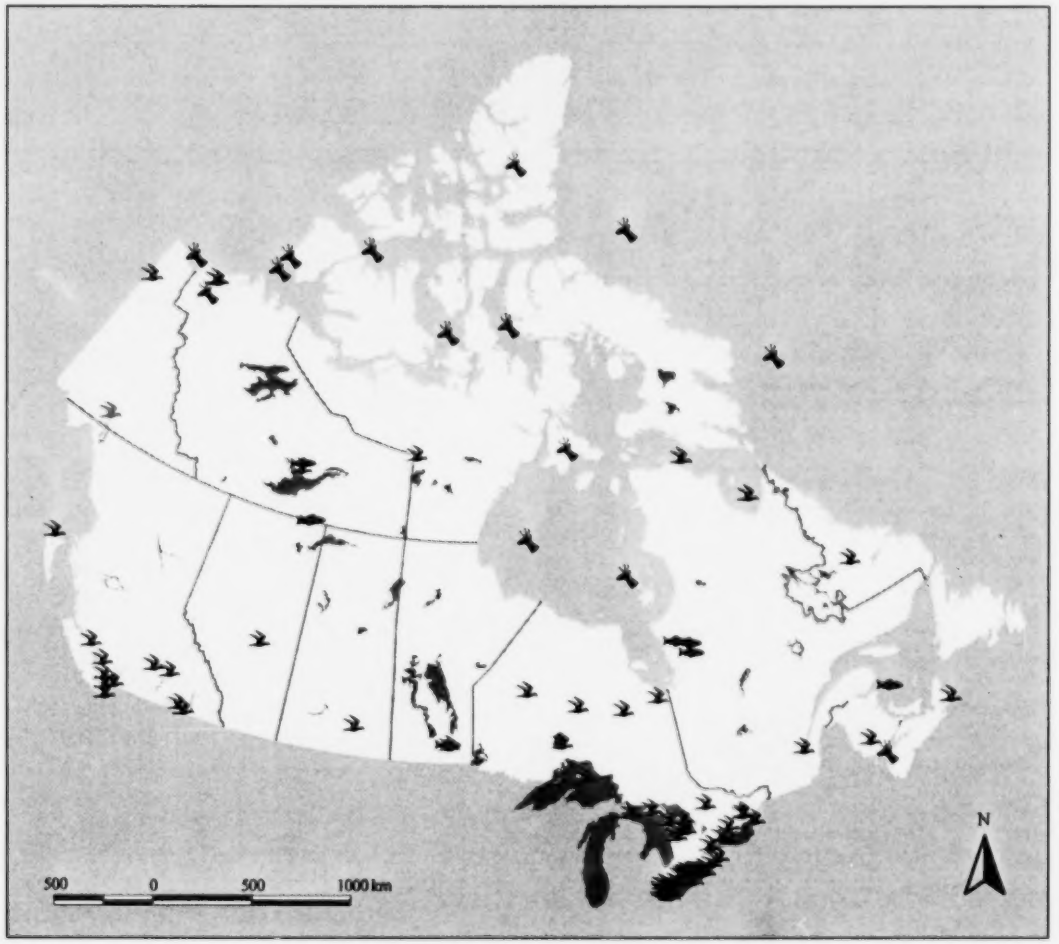


Taxa

- Birds
- Fish
- Mammals
- Herpetofauna
- Other
- Mixed

Taxa	Number of Programs	Number of Monitoring Sites
Birds	5	71
Fish	8	62
Mammals	3	38
Herpetofauna	0	0
Other	3	3
Mixed	4	7
All Taxa	17	175

Figure 5. Completed Canadian contaminant programs - sites monitored for mercury.

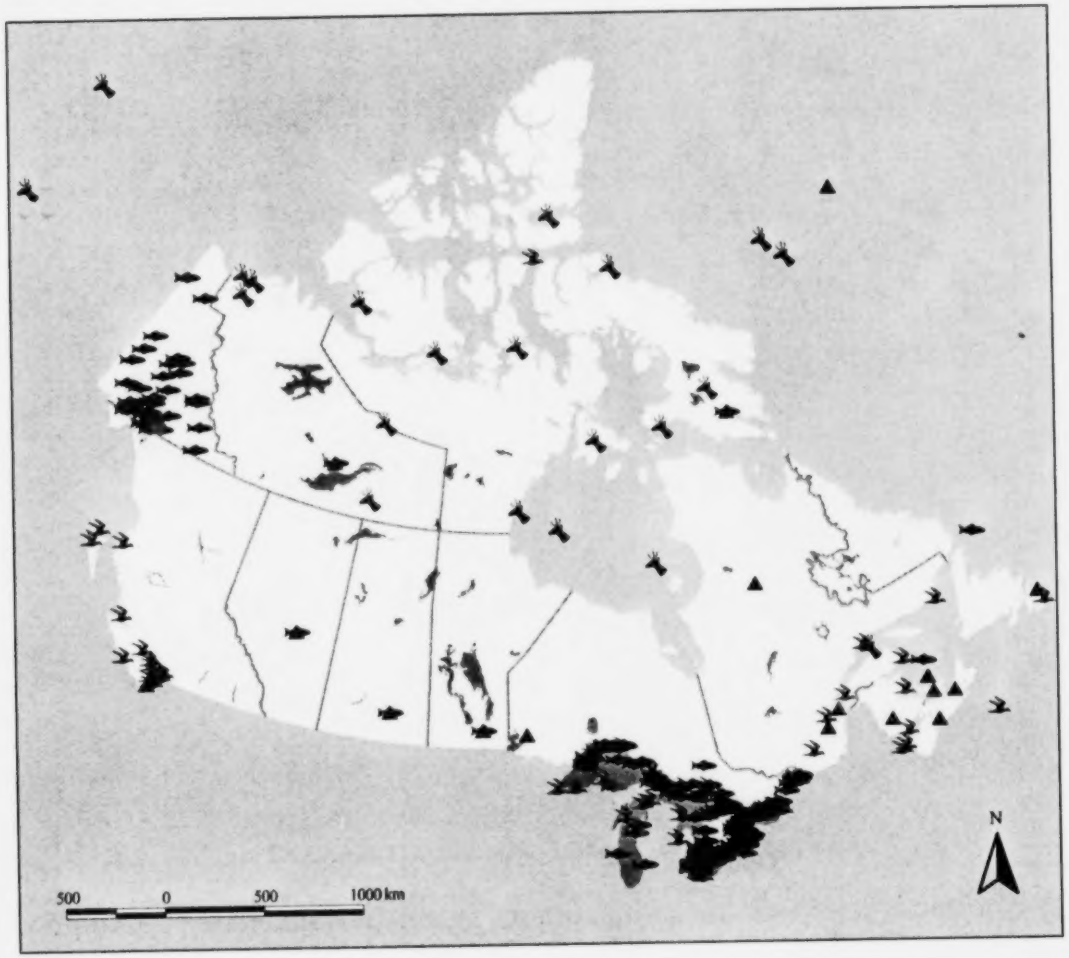


Taxa

- Birds
- Fish
- Mammals
- Herpetofauna
- Other
- Mixed

Taxa	Number of Programs	Number of Monitoring Sites
Birds	7	84
Fish	4	8
Mammals	4	14
Herpetofauna	0	0
Other	0	0
Mixed	0	0
All Taxa	15	106

Figure 6. Ongoing Canadian contaminant programs - sites monitored for organic chemicals.

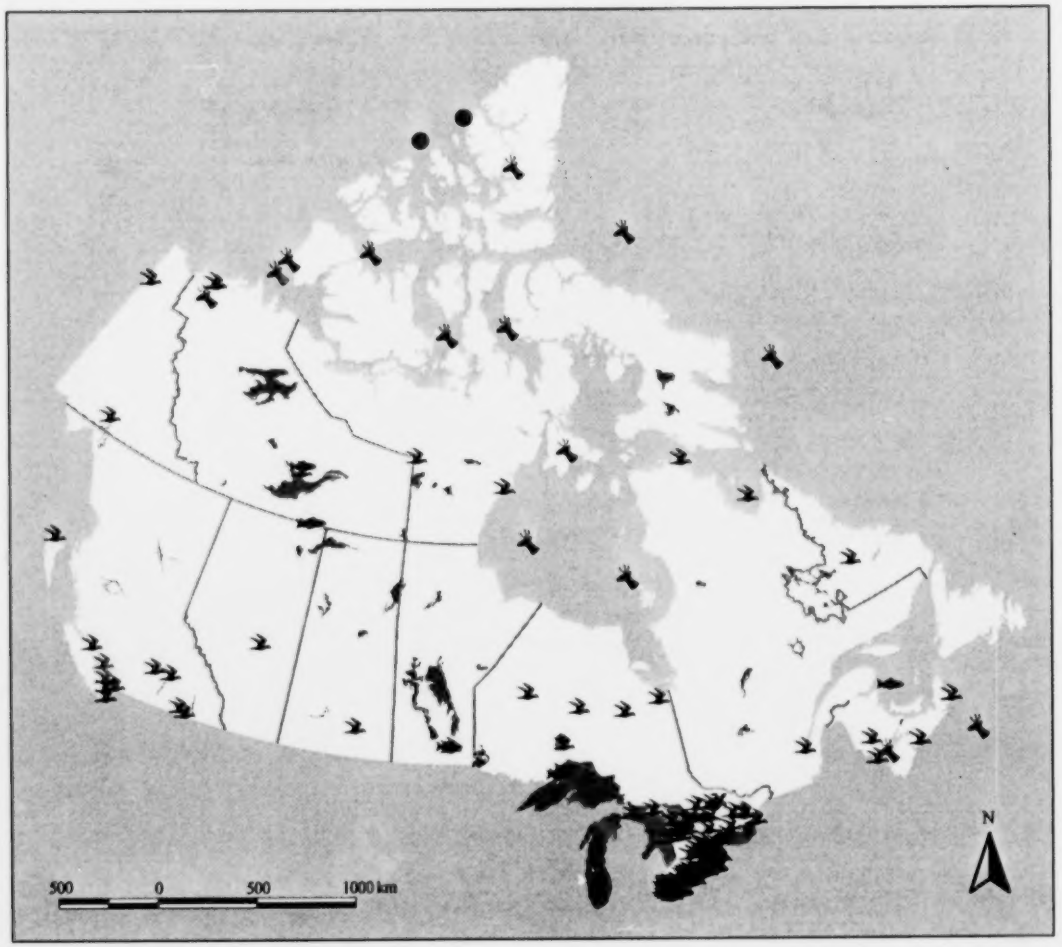


Taxa

- Birds
- Fish
- Mammals
- Herpetofauna
- Other
- Mixed

Taxa	Number of Programs	Number of Monitoring Sites
Birds	8	87
Fish	12	240
Mammals	5	34
Herpetofauna	0	0
Other	5	17
Mixed	6	21
All Taxa	25	353

Figure 7. Completed Canadian contaminant programs - sites monitored for organic chemicals.

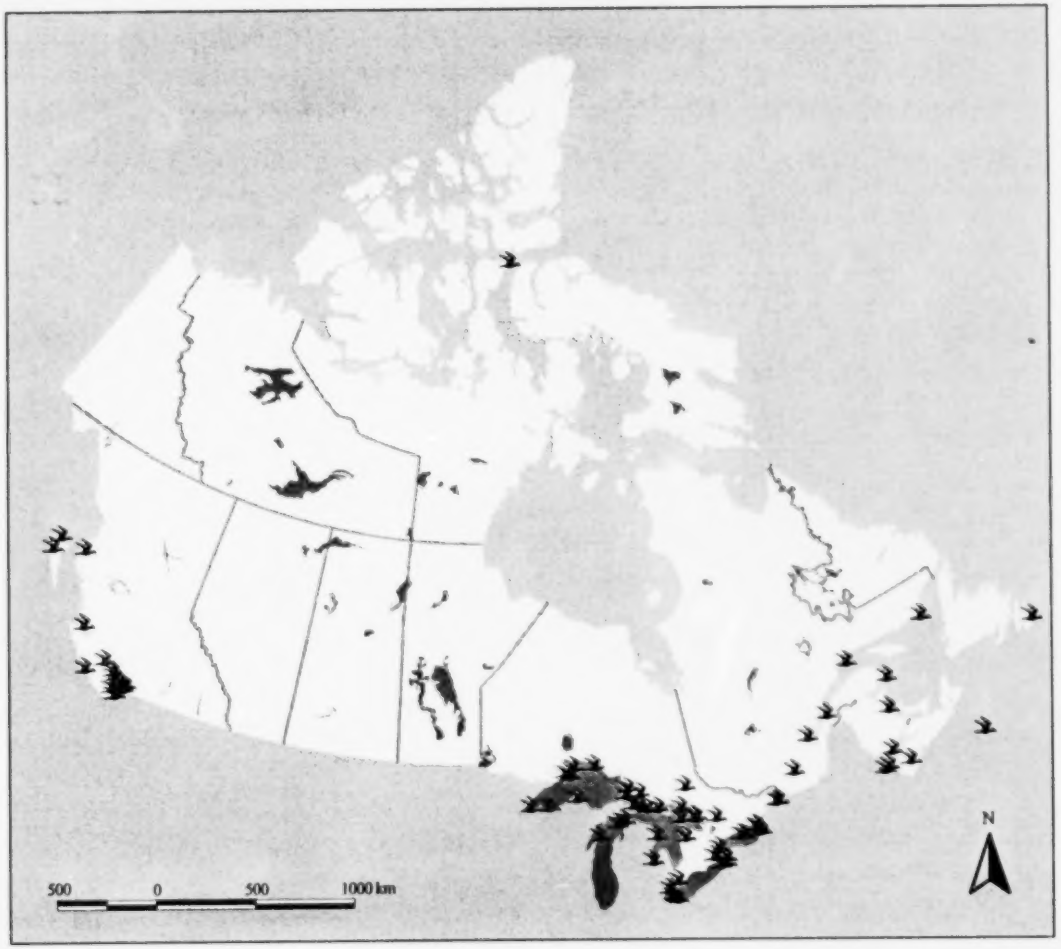


Taxa

- Birds
- Fish
- Mammals
- Herpetofauna
- Other
- Mixed

Taxa	Number of Programs	Number of Monitoring Sites
Birds	13	109
Fish	4	26
Mammals	4	14
Herpetofauna	1	6
Other	1	2
Mixed	0	0
All Taxa	23	157

Figure 8. Ongoing Canadian contaminant programs - avian monitoring sites.

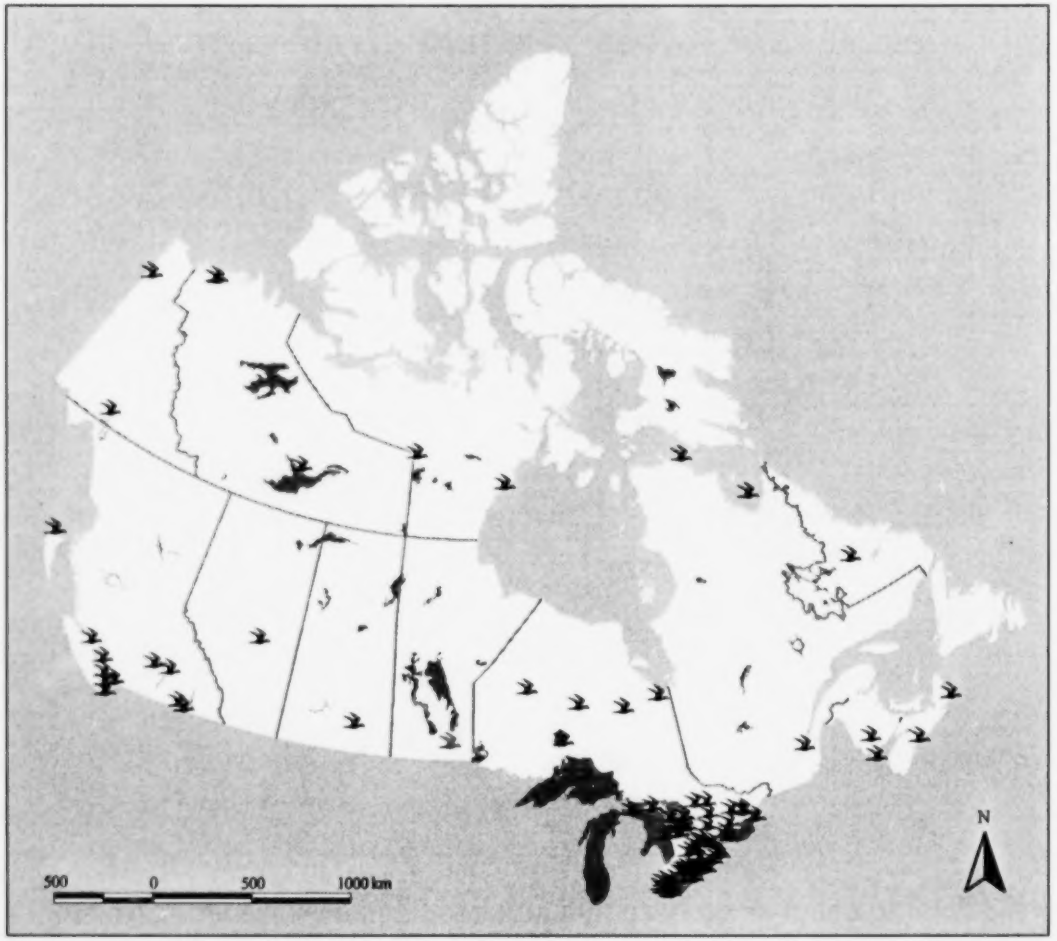


Taxa

Birds

Taxa	Number of Programs	Number of Monitoring Sites
Birds	9	91

Figure 9. Completed Canadian contaminant programs - avian monitoring sites.

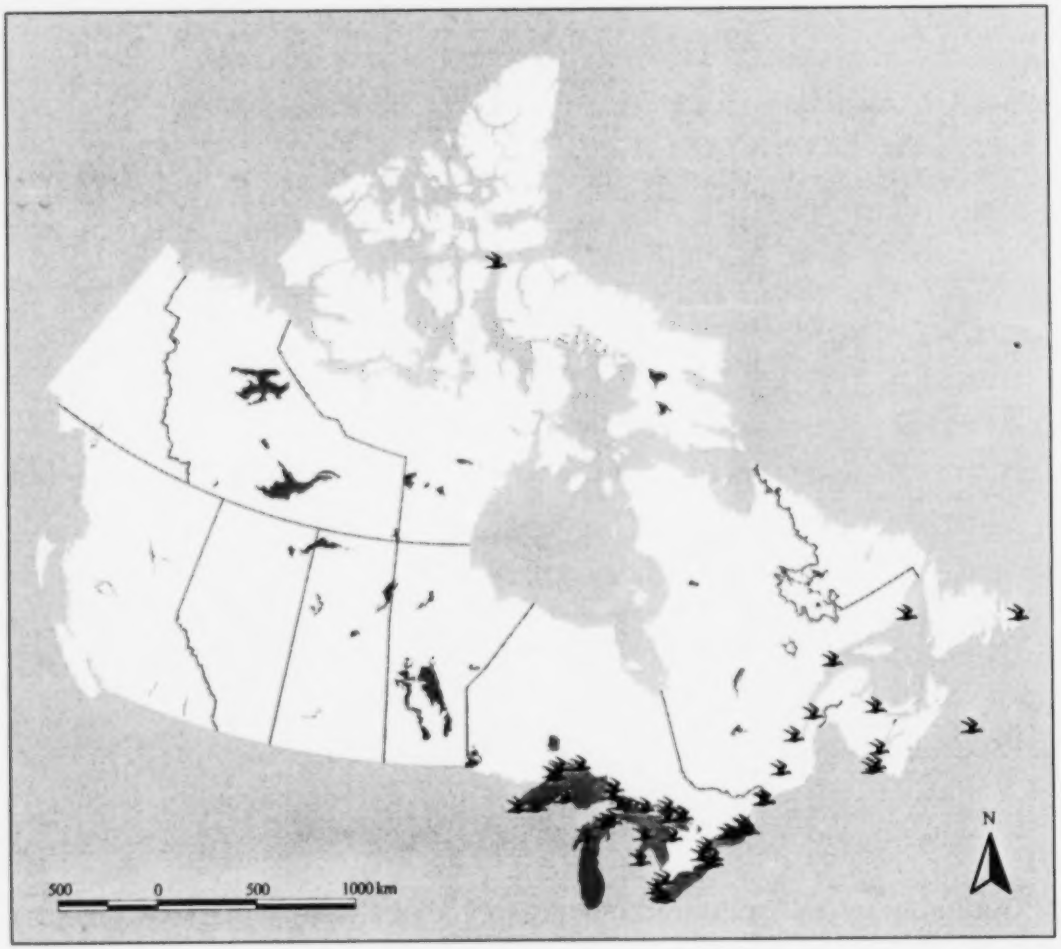


Taxa

Birds

Taxa	Number of Programs	Number of Monitoring Sites
Birds	13	109

Figure 10. Ongoing Canadian contaminant programs - avian monitoring sites for mercury.

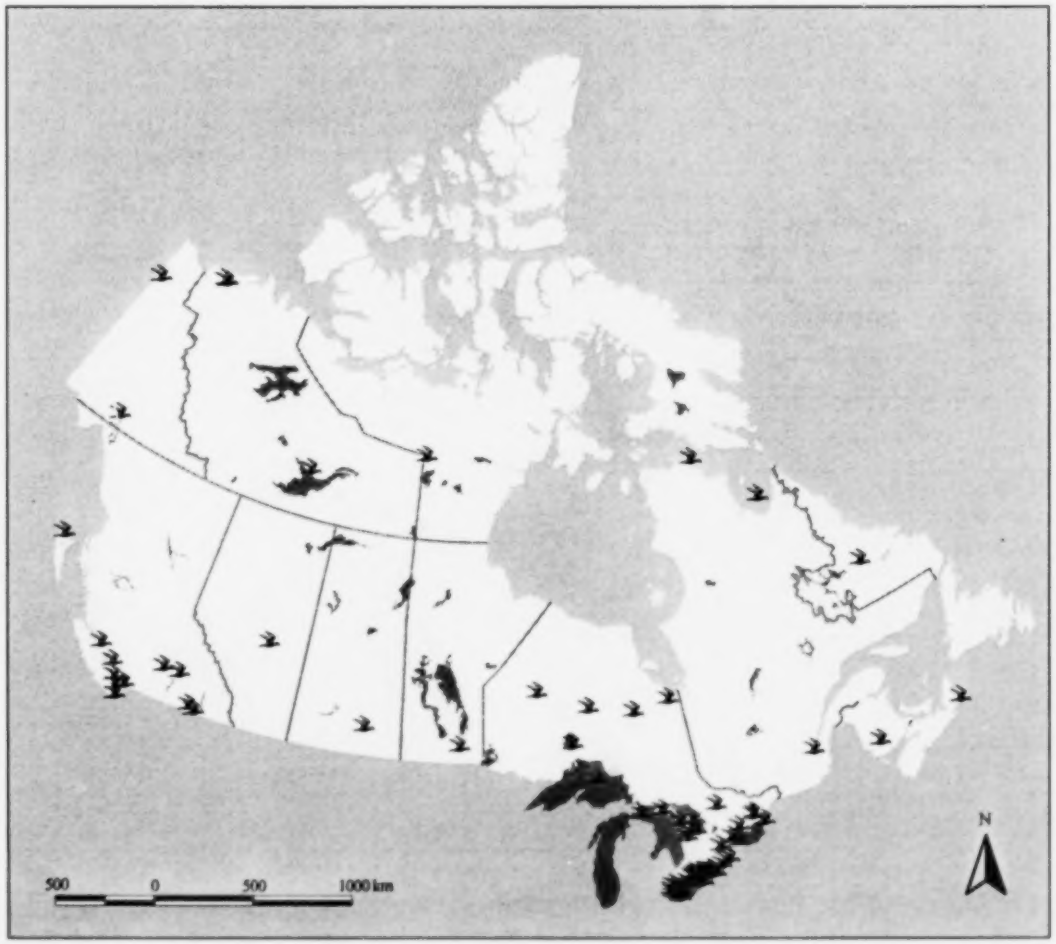


Taxa

Birds

Taxa	Number of Programs	Number of Monitoring Sites
Birds	5	71

Figure 11. Completed Canadian contaminant programs - avian monitoring sites for mercury.

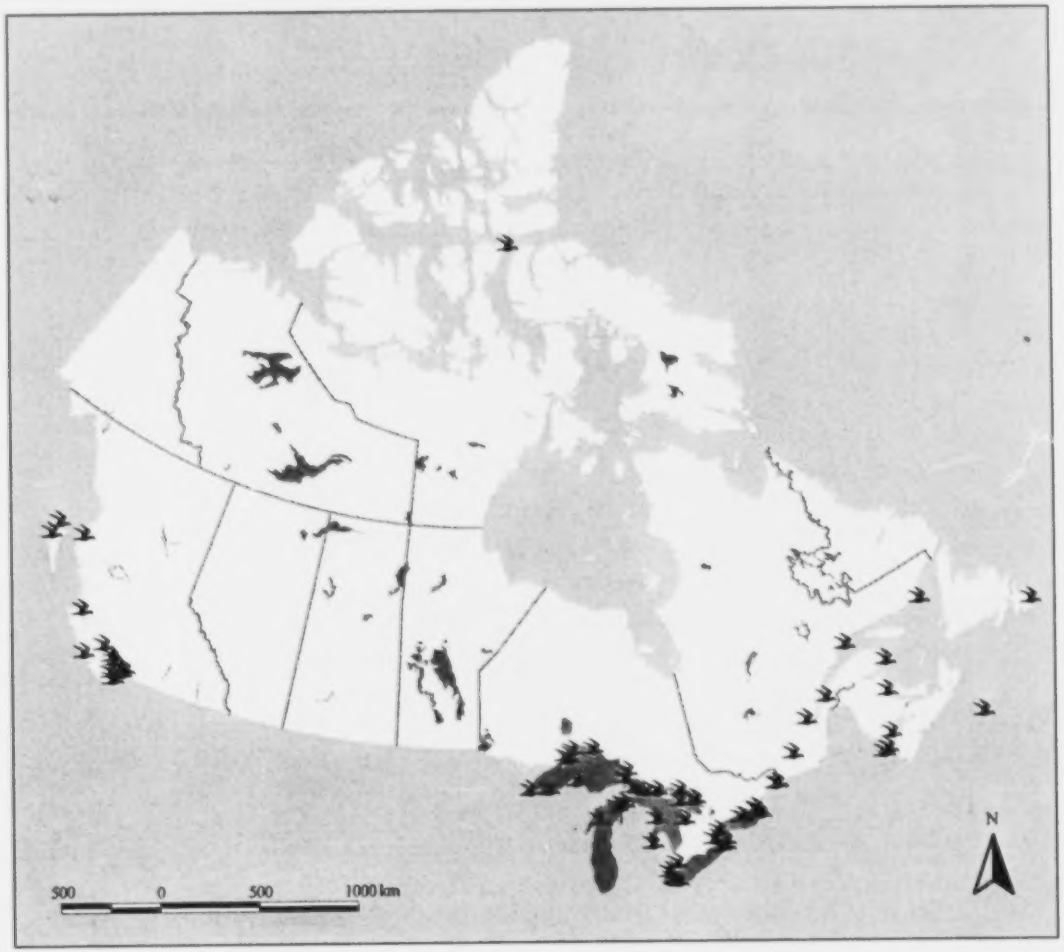


Taxa

Birds

Taxa	Number of Programs	Number of Monitoring Sites
Birds	7	84

Figure 12. Ongoing Canadian contaminant programs - avian monitoring sites for organic chemicals.

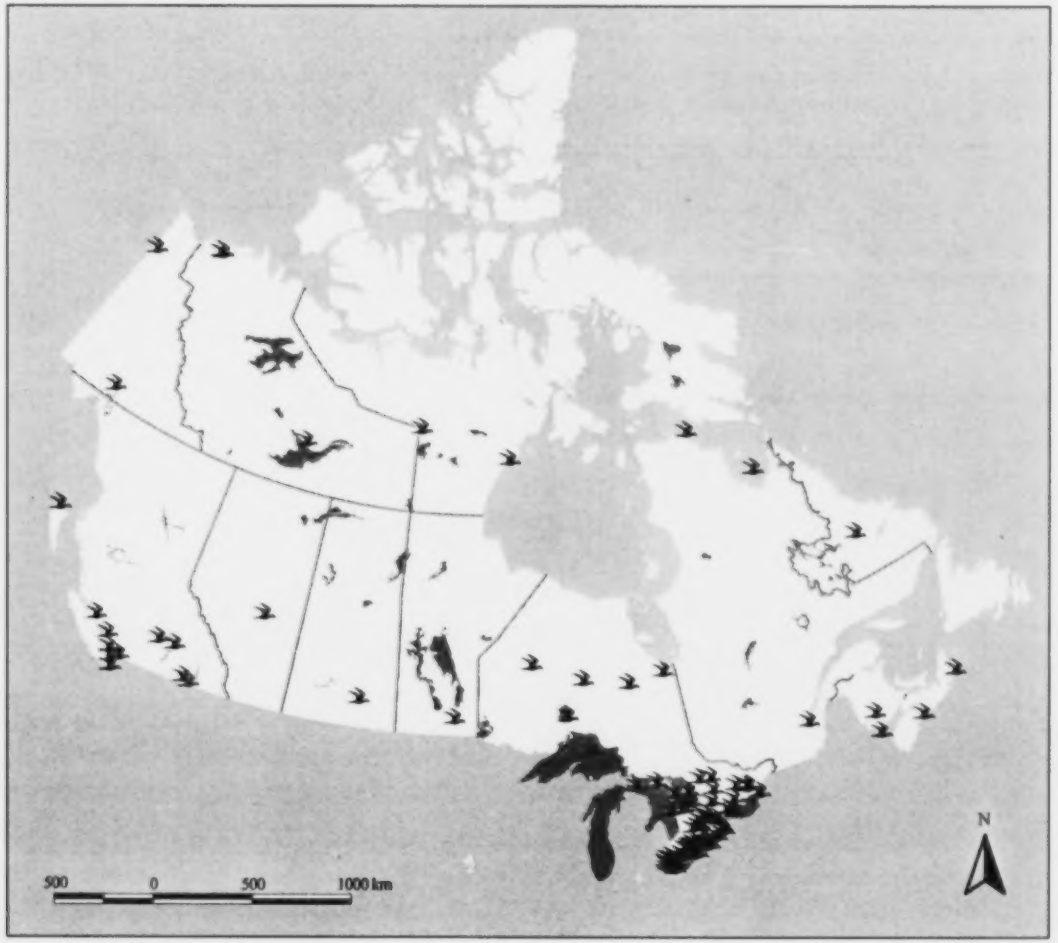


Taxa

Birds

Taxa	Number of Programs	Number of Monitoring Sites
Birds	8	87

Figure 13. Completed Canadian contaminant programs - avian monitoring sites for organic chemicals.

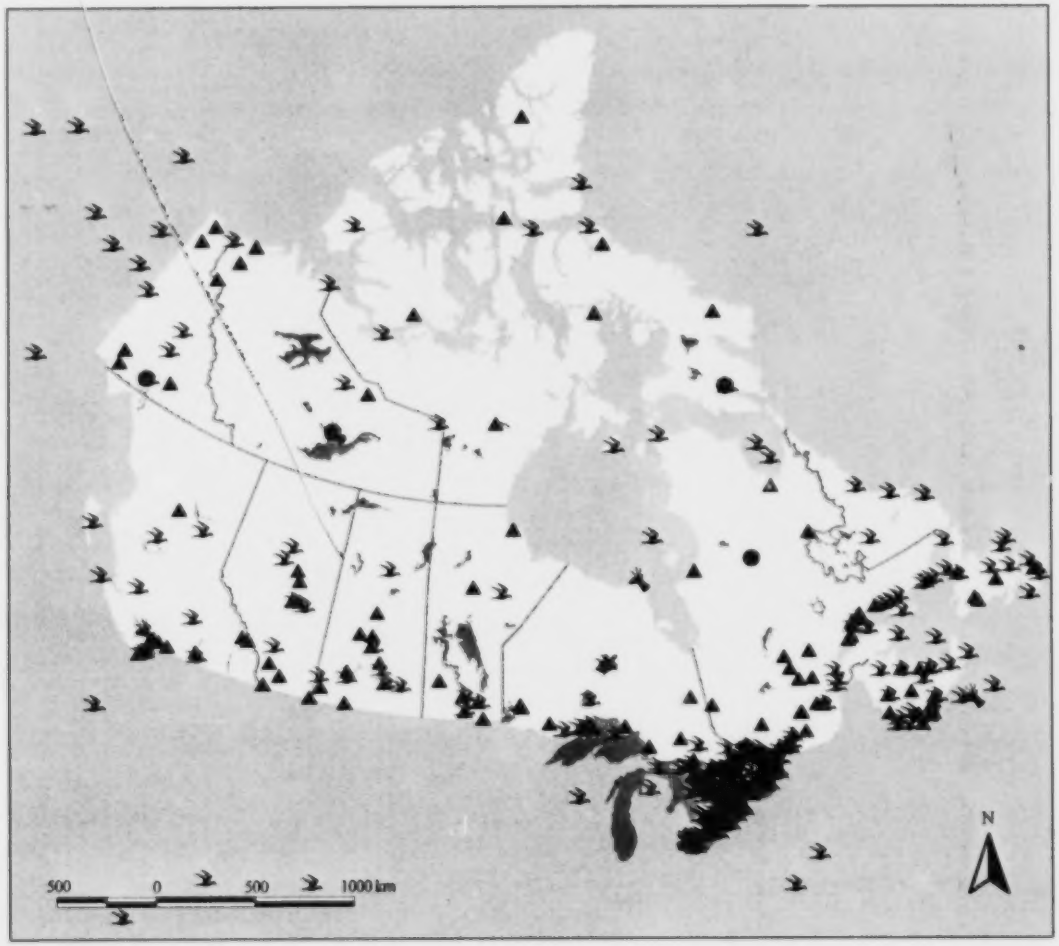


Taxa

Birds

Taxa	Number of Programs	Number of Monitoring Sites
Birds	13	109

Figure 14. Ongoing Canadian ecological programs - monitoring sites.

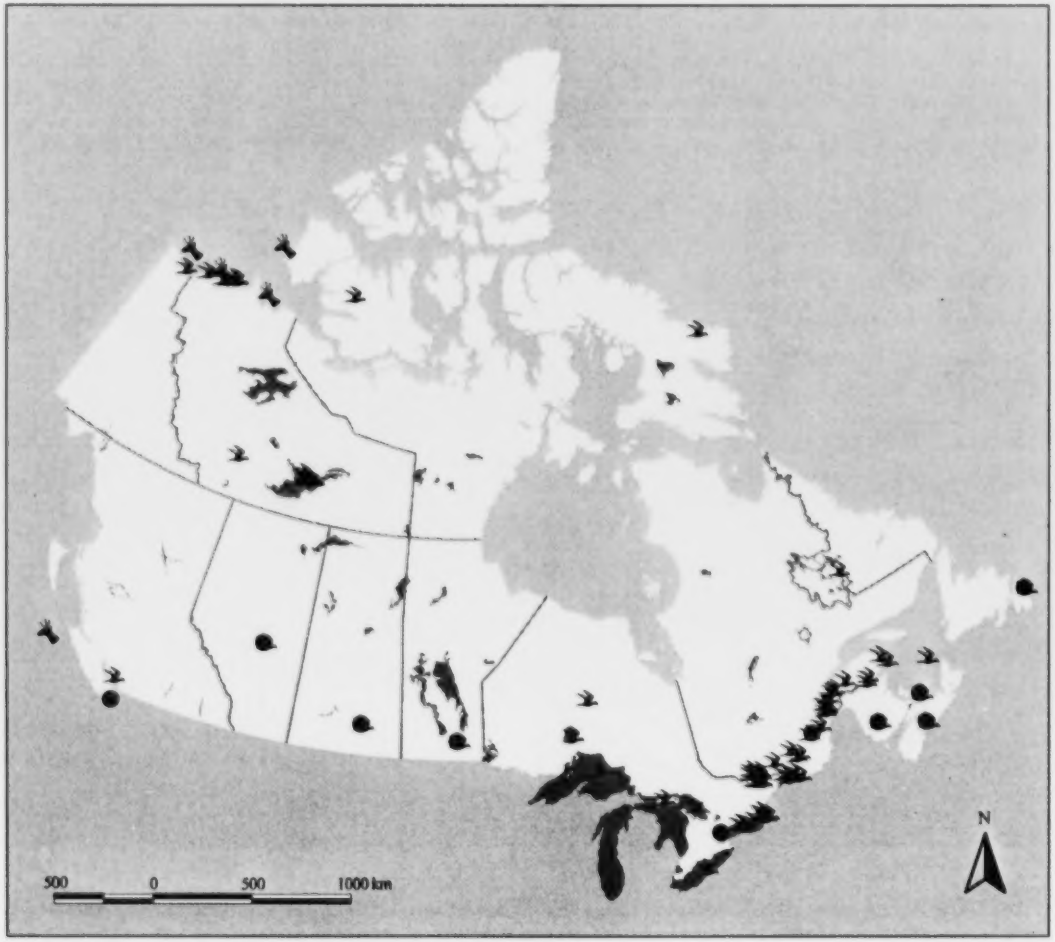


Taxa

- Birds
- Fish
- Mammals
- Herpetofauna
- Other
- Mixed

Taxa	Number of Programs	Number of Monitoring Sites
Birds	26	449
Fish	2	49
Mammals	4	4
Herpetofauna	2	92
Other	6	155
Mixed	5	151
All Taxa	37	610

Figure 15. Completed Canadian ecological programs - monitoring sites.

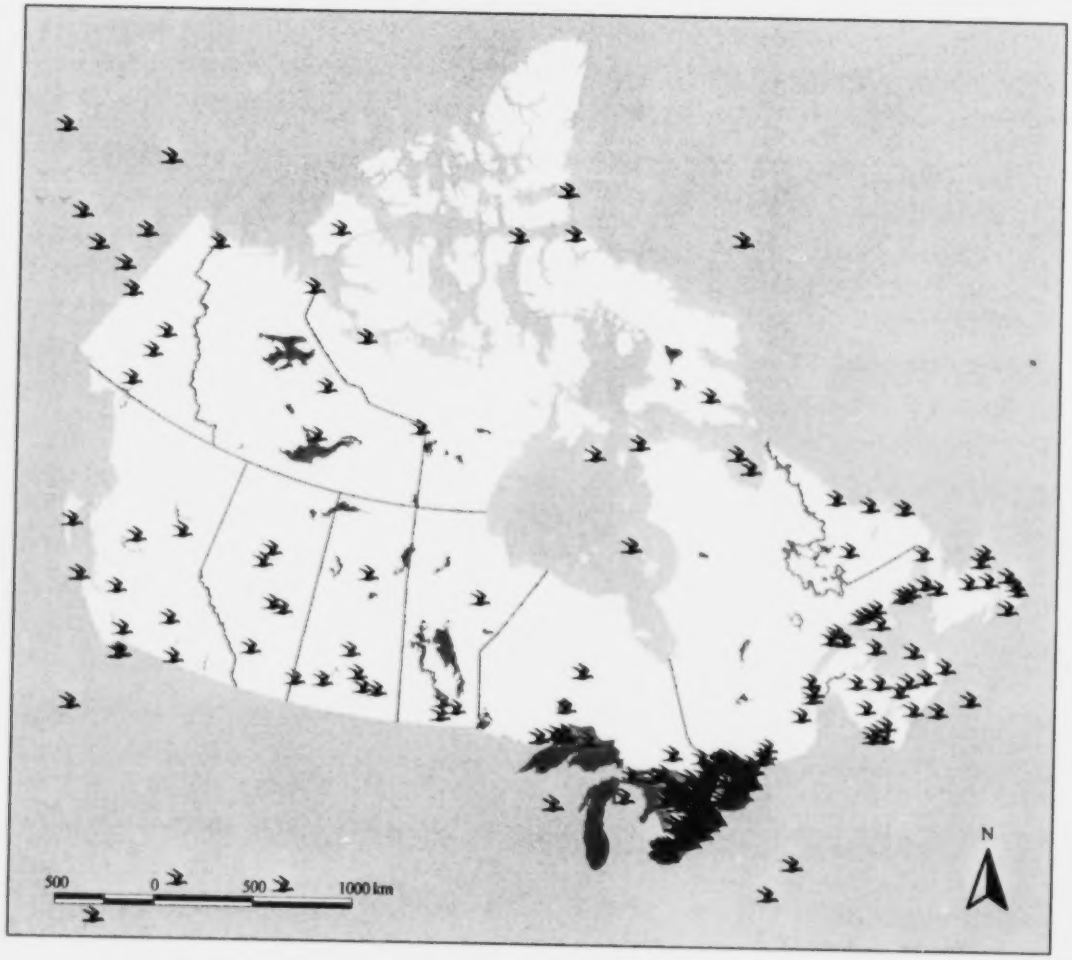


Taxa

- Birds
- Fish
- Mammals
- Herpetofauna
- Other
- Mixed

Taxa	Number of Programs	Number of Monitoring Sites
Birds	12	84
Fish	0	0
Mammals	2	5
Herpetofauna	0	0
Other	1	10
Mixed	0	0
All Taxa	15	99

Figure 16. Ongoing Canadian ecological programs - avian monitoring sites.

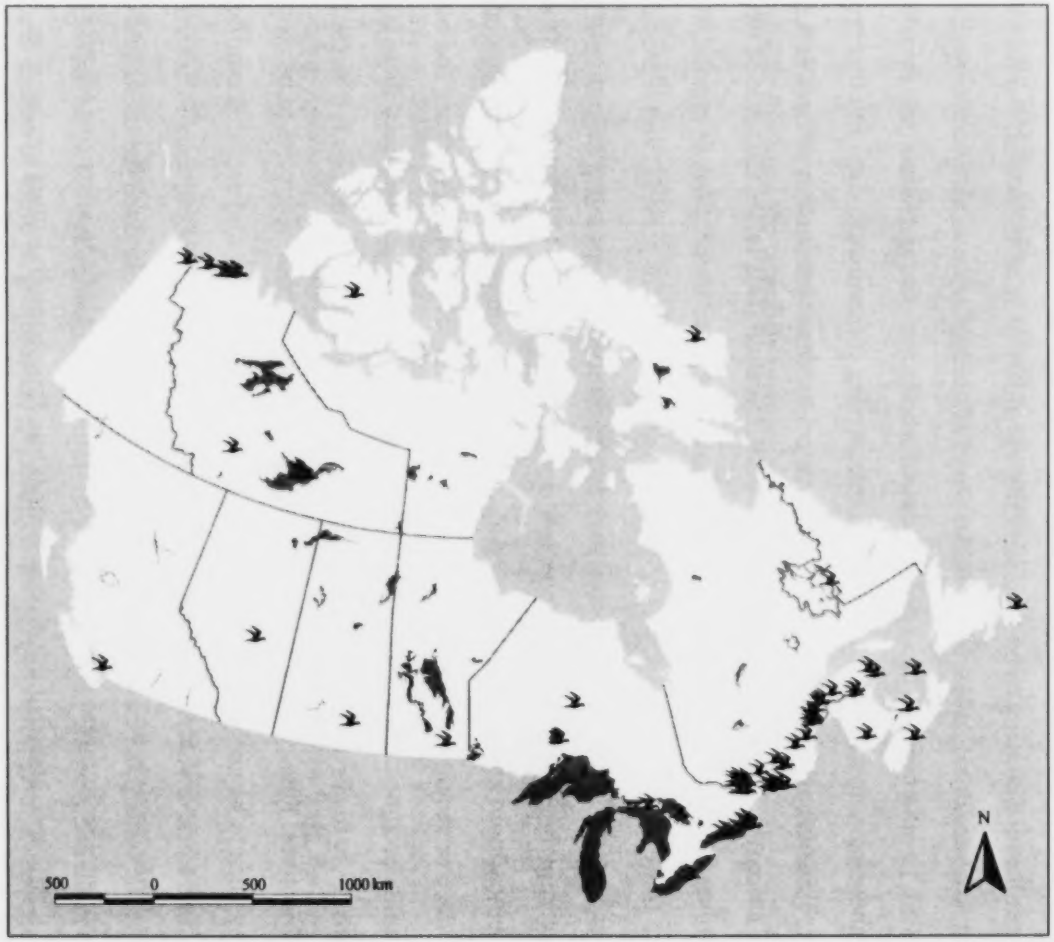


Taxa

Birds

Taxa	Number of Programs	Number of Monitoring Sites
Birds	26	449

Figure 17. Completed Canadian ecological programs - avian monitoring sites.



Taxa

Birds

Taxa	Number of Programs	Number of Monitoring Sites
Birds	12	84

6.2.2 Can CWS contaminant monitoring programs be improved?

There is always room for improvement but if a monitoring program has multiple objectives, it will not necessarily satisfy all of those objectives equally. For the "flagship" CWS contaminant monitoring programs, the suggestion has been made to scale back the number of colonies monitored under a given program to a core group. In order to achieve this, does one retain those colonies for which population data are available, or does one focus strictly on local contamination problems? There are several factors which must be taken into consideration. Clearly, there is a desire to retain data continuity for at least a few colonies. This is essential to maintain the historical record. The next issue deals with the availability of population data for those colonies which are to be monitored for contaminant-related reasons. For the Great Lakes and Arctic monitoring sites, in particular, population data are available for the species being sampled. In other areas, it must be questioned whether or not population data for other neighbouring colonies may be utilized in interpreting contaminants data. In other words, although highly desirable, is it really necessary to have population/reproductive success data from the same colony which is being monitored for contaminants? This raises the issue of whether or not CWS is interested in monitoring individual health or population health. If population/ ecosystem health is the issue, then as long as populations are stable (or increasing) and reproductive success is at acceptable levels overall, then it may not be necessary to have population/ecosystem data for each colony being monitored for contaminants. However, if the health of a specific colony is being monitored as a reflection of a local contaminant problem, then data on population numbers, reproductive success and pathology in addition to levels of chemical residues and biochemical endpoints become critical. The choice of species also becomes critical since there is a wide range of sensitivity to chemical stressors among species. The discussion comes full circle to defining the objectives. Finally, the accessibility of colonies and number of species to be monitored per colony need to be analyzed to determine the most cost-efficient and useful scenarios. There would be a cost involved in the integration of ecological and contaminants monitoring programs. During the transition phase, there would, in fact, have to be increased contaminants monitoring since monitoring would have to continue at traditional colonies as well as be initiated at new colonies where ecological/population monitoring is occurring in order to ensure that the contaminant trends are parallel amongst colonies and no historical perspective is lost. As has

already been pointed out, in the end, it all comes down to examining which questions the monitoring programs were designed to answer, and determining whether or not those questions are still relevant today. In other words, what is the future objective in monitoring? Monitoring objectives vary from region to region driven by local concerns and funding. This will, in large part, determine which species and colonies are chosen/retained and what the sampling interval will be. This assessment can only provide the tools for the process of potential program change and not the outcome as that is a regional decision requiring the input of regional managers and contaminants and population biologists alike.

6.2.3 How should CWS continue to monitor contaminants?

Harding (1992) pointed out that, according to the Marine Board of the U.S. National Academy of Sciences, a successful monitoring program depends upon the following factors:

- Goals and objectives must be clearly articulated in terms that are meaningful to the public and provide the basis for scientific investigation.
- Attention must be paid to, and adequate resources provided over the long term, for the management, synthesis, interpretation and analysis of the data generated by monitoring.
- Quality assurance procedures must include peer review.
- Because even well designed monitoring results in unanswered questions about environmental processes or human impacts, supportive research must be provided.
- Programs must be sufficiently flexible to allow for modification where changes in conditions or new information indicate the need.
- Monitoring information should be available to all interested parties in a form that is useful to them.

It is clear that the federal government must retain the capacity to assess new contaminant issues and give them context. The monitoring of contaminants in wildlife is not an activity which would be undertaken by the private or academic sector. Therefore it is not a question of whether or not CWS should continue to monitor contaminants and their effects in wildlife, but how. The specific objective(s) of the monitoring program will determine the number and type of species

chosen. The species chosen for the "flagship" CWS contaminant monitoring programs were carefully selected based on a set of criteria described in Sections 2.1 and 2.2. However, other species have been, and should continue to be, utilized for monitoring to address specific problems/questions or specific environments, as appropriate. As discussed in Section 2.2.3, species such as raptors, reptiles and polar bears have been monitored by CWS in response to specific issues or problems. Most of these other programs have since been terminated and some continue on a sporadic basis. However, because all of the samples have been archived in the CWS Specimen Bank, the opportunity exists to revive any of these programs since both data and samples are available for temporal trend comparisons. This sort of flexibility must be maintained so that CWS has the means to respond to new and emerging issues. It could even be argued that certain programs targeting species such as raptors and reptiles, for instance, should be revived on a limited basis with sample collections being made at strategic locations at least every ten years so that the potential exists to address future issues in terrestrial, riparian, and other freshwater ecosystems outside of the Great Lakes Basin as well as in the marine/aquatic ecosystems on which CWS has focused so much of its monitoring efforts.

Avian eggs, as well as reptilian eggs, have been shown to be good temporal monitors of POPs and mercury although different tissues must be considered to monitor metals other than mercury since metals such as cadmium and lead are not readily transferred into avian eggs (Sell 1975; Leonzio and Massi 1989). Where possible, and where population numbers permit, it would be useful to collect a number of adult specimens every ten years in the ongoing programs so that other tissues such as liver and kidney are available to examine trends of metals as well as the transfer ratio of new chemicals from liver to egg in order to determine the utility of avian eggs as a monitoring medium for that new compound. Archived liver tissue for "flagship" CWS contaminant program species is available at sporadic intervals in the past, but standardization of this sampling interval would be useful. It is not necessary that those samples be chemically analyzed at the time of collection. Tissues other than eggs have been sampled in programs as the situation warrants. For example, fat biopsies are routinely sampled from polar bears and blood has been sampled from raptors and other avian species. Blood can be a useful sampling medium (see Elliott and Shutt 1993), particularly for species whose populations are in decline and where

nondestructive sampling, or serial sampling, are essential. Blood is also the best matrix for analysis of persistent phenolic contaminants such as pentachlorophenol and PCB metabolites (Sandau et al. 2000).

In its 1990 State of the Environment Report (Noble 1990), Environment Canada stated that the CWS seabird monitoring program "*will continue more or less as originally planned, with some minor modifications in sampling design.*" This statement is still valid today and embraces the premise that monitoring is not a static activity but open to justified change. For example, as a result of Canada's participation in the circumpolar Arctic Monitoring and Assessment Program (AMAP), and with support from the NCP, two additional species, the black guillemot and the glaucous gull, were added to the sampling protocol of the arctic seabird monitoring program in 1993 to facilitate comparisons with other circumpolar monitoring programs. As well, as of 1993, sample collections were standardized to five-year intervals. Here is an example of how an interested partner facilitated change through the infusion of resources. Partners, however, will change with shifting interests and resources whereas monitoring activities must continue in a systematic fashion in order to be of value. Partners are important to monitoring programs as contributors of logistical support and funding as well as providing an outlet for the resulting data but they should not be the sole impetus for monitoring activities. Monitoring programs must hold their options open. In 1990, Environment Canada made public its plans for preliminary surveys of metals in marine birds using the CWS monitoring programs (Noble 1990). Since then, retrospective surveys of mercury in eggs have been undertaken in all of the "flagship" programs (Koster et al. 1996; Braune et al. 2001; Burgess and Braune 2001; CWS, unpubl. data) in addition to surveys of a wider range of metals in seabird tissues (Elliott et al. 1992b; CWS, unpubl. data). In that same report, Environment Canada repeated Tanabe's (1988) suggestion that PCB pollution will continue to increase in the environment over the next decade or two because of the high proportion of PCBs still present in electrical equipment, in sediments, and in the immense reservoirs of the world's oceans. Through the continuation of its programs, CWS has been able to monitor the situation in wildlife closely and should be allowed to continue to do so for the historical contaminants such as PCBs as well as the newer compounds such as PBDEs.

The CWS contaminant monitoring programs that currently exist have been set up in areas that are at greatest risk to chemical exposure. New contaminant monitoring programs should only be initiated in new areas in response to investigative or research efforts which identify specific threats. This also holds true for the addition of new analytes to the suite of compounds regularly analyzed. Research is required to build the case for their inclusion and sound methodology must be available. CWS does not have the resources to greatly expand its monitoring efforts beyond those activities which it currently supports. As demonstrated in Sections 4 and 5, more frequent sampling does provide tangible benefits from a monitoring perspective. The current collection regimes for the marine seabird monitoring programs are not optimal. It could be argued that the increased collection costs would likely be offset by the improvement in the usefulness of the data. However, as discussed earlier, whether or not the improved quality of the monitoring data merits the additional resources that would be required to monitor on an annual basis is as much driven by priorities as science and will reflect the balance between the cost of the program and collecting data in a manner that allows us to answer critical questions. This is very much a management decision.

6.3 Funding and Partners

Monitoring programs yield good value for the resources invested. Over the past decade, CWS contaminant monitoring activities have been financially supported by the Northern Contaminants Program and Great Lakes funding as well as receiving regional logistical support. This has created a strong partnership between NWRC and the regions as well as other departments such as Indian and Northern Affairs Canada. The resulting data have been used by numerous national and international programs/agencies (e.g. International Joint Commission, Great Lakes Action Plans, Northern Contaminants Program, Arctic Monitoring and Assessment Program, Marine Environmental Quality Program, Ocean Dumping Program, State of the Environment Reports). A survey of the peer-reviewed literature by time periods (Table 2) illustrates the impact of published articles related to the "flagship" CWS contaminant monitoring programs. Clearly, the data produced by CWS contaminant monitoring programs are being widely utilized, both nationally and internationally, in the development of policy, and in remediation and assessment activities.

7. Summary and Recommendations

Common objections to monitoring include the arguments that (i) monitoring is an open-ended commitment, and (ii) monitoring must have a clear rationale; in other words, we should not just monitor populations for the sake of it. However, monitoring serves as an early warning mechanism to trigger management response or further research. Combined with research results, monitoring is critical for informed decision-making by management. It has been argued that long-term chemical monitoring programs are a waste of time and resources if their primary purpose has become the tracking of long-term environmental trends, and the species monitored are not at risk. However, once there are obvious effects observed at the population level, it is often too late. Although CWS long-term monitoring programs generally were created in reaction to a problem, their continuation may be considered a proactive activity.

CWS chemical monitoring programs have provided some of the best data in the world on the environmental behaviour of POPs and are one of the principal tools we have for measuring the impact that controls of these substances have on their (biologically available) environmental concentrations. If a federal agency such as CWS did not do this monitoring, it is unclear what other agency would have undertaken these programs, maintained them and had the foresight and means to archive the resulting samples for future use.

Long-term contaminant monitoring programs provide important data that allow us to evaluate our impact on the environment. Continuation of these monitoring programs into the foreseeable future should be a priority and program enhancement should be considered in light of program objectives. Recommendations for program enhancement include:

- Increasing the frequency of sampling for those programs not sampling on an annual basis
- Where possible, and where population numbers permit, collection of adult specimens every eight or ten years to provide tissues for analyses of metals and new contaminants, as well as other research
- Better integration of population and contaminants monitoring programs

- Better integration of contaminant effects research with research evaluating the relative importance of other stressors, e.g. disease, food availability

- Revival on a limited basis of monitoring programs targeting species such as raptors and reptiles to maintain the potential to address future issues in terrestrial and riparian ecosystems

- Assessing the need for the addition of programs outside of the Great Lakes Basin to monitor contaminants in terrestrial and freshwater ecosystems across Canada

Literature cited

Addison, R.F.; Smith, T.G. 1998. Trends in organochlorine residue concentrations in ringed seal (*Phoca hispida*) from Holman, Northwest Territories, 1972-91. Arctic 51: 253-261.

Addison, R.F.; Stobo, W.T. 2001. Trends in organochlorine residue concentrations and burdens in grey seals (*Halichoerus grypus*) from Sable Is., NS, Canada, between 1974 and 1994. Environ. Pollut. 112: 505-513.

Alaee, M.; Bunce, N.; Ikonomou, M.; Lebeuf, M.; Metcalfe, C.; Muir, D.; Sergeant, D.; Solomon, K.; Ryan, J.; Wakeford, B.; Whittle, M. 2002. Determination of the impact of polybrominated diphenyl ethers to Canadian environment and health of Canadians. National Conference of the Toxic Substances Research Initiative, March 5-8, 2002, Ottawa, ON.

Baumann, P.C.; Whittle, D.M. 1988. The status of selected organics in the Laurentian Great Lakes: an overview of DDT, PCBs, dioxins, furans, and aromatic hydrocarbons. Aquat. Toxicol. 11: 241-257.

Bidleman, T.F.; Falconer, R.L.; Walla, M.D. 1995a. Toxaphene and other organochlorine compounds in air and water at Resolute Bay, N.W.T., Canada. Sci. Total Environ. 160/161: 55-63.

Bidleman, T.F.; Jantunen, L.M.; Falconer, R.L.; Barrie, L.A.; Fellin, P. 1995b. Decline of hexachlorocyclohexanes in the arctic atmosphere and reversal of air-sea gas exchange. Geophys. Res. Lett. 22: 219-222.

Bignert, A.; Göthberg, A.; Jensen, S.; Litzén, K.; Odsjö, T.; Olsson, M.; Reutergardh, L. 1993. The need for adequate biological sampling in ecotoxicological investigations: a retrospective study of twenty years pollution monitoring. Sci. Total Environ. 128: 121-139.

Bignert, A.; Olsson, M.; de Wit, C.; Litzén, K.; Rappe, C.; Reutergardh, L. 1994. Biological variation - an important factor to consider in ecotoxicological studies based on environmental samples. Fres. J. Anal. Chem. 348: 76-85.

Bignert, A.; Olsson, M.; Persson, W.; Jensen, S.; Zakrisson, S.; Litzén, K.; Eriksson, U.; Häggberg, L.; Alsberg, T. 1998. Temporal trends of organochlorines in Northern Europe, 1967-1995. Relation to global fractionation, leakage from sediments and international measures. Environ. Pollut. 99: 177-198.

Bishop, C.A.; Weseloh, D.V.; Burgess, N.B.; Norstrom, R.J.; Turle, R.; Logan, K.A. 1992. An atlas of contaminants in eggs of colonial fish-eating birds of the Great Lakes (1970-1988): Vols. I and II. Canadian Wildlife Service, Technical Report Series, No.153.

Bishop, C.A.; Gendron, A.D. 1998. Reptiles and amphibians: shy and sensitive vertebrates of the Great Lakes Basin and St. Lawrence River. Environ. Monit. Assess. 53: 225-244.

Borgmann, U.; Whittle, D.M. 1991. Contaminant concentration trends in Lake Ontario lake trout (*Salvelinus namaycush*): 1977 to 1988. J. Great Lakes Res. 17: 368-381.

Braune, B.M. 2001. Retrospective survey of organochlorines and mercury in arctic seabird eggs. Pages 160-165 *in* S. Kalhok (ed.), Synopsis of Research Conducted Under the 2000-2001 Northern Contaminants Program. Indian and Northern Affairs Canada, Ottawa.

Braune, B.M.; Norstrom, R.J.; Wong, M.P.; Collins, B.T.; Lee, J. 1991. Geographical distribution of metals in livers of polar bears from the Northwest Territories, Canada. Sci. Total Environ. 100: 283-299.

Braune, B.M.; Donaldson, G.M.; Hobson, K.A. 2001. Contaminant residues in seabird eggs from the Canadian Arctic. I. Temporal trends 1975 - 1998. Environ. Pollut. 114: 39-54.

Braune, B.M.; Simon, M. Dioxins, furans and non-ortho PCBs in Canadian Arctic seabirds. (submitted to Environ. Sci. Technol.)

Burgess, N.M.; Braune, B.M. 2001. Increasing trends in mercury concentrations in Atlantic and Arctic seabird eggs in Canada. 11th Annual Meeting of SETAC-Europe, Madrid, Spain.

Cash, K.J.; Wrona, F.J.; Gummer, W.D. 1996. Ecosystem Health and Integrated Monitoring in the Northern River Basins. Northern River Basins Study Synthesis Report No. 10, Edmonton, Alberta, 1996.

Champoux, L.; DesGranges, J.-L.; Rodrigue, J.; Hontela, A.; Trudeau, S.; Spear, P.E. 2000. Ivaluation d'indicateurs biochimiques chez le grand héron, *Ardea herodias*, et le bihoreau gris, *Nycticorax nycticorax*, en relation avec la contamination du fleuve Saint-Laurent. Tech Rep Ser No 354. Canadian Wildlife Service, Quebec Region.

Champoux, L.; Rodrigue, J.; DesGranges, J.-L.; Trudeau, S.; Hontela, A.; Boily, M.; Spear, P. 2002. Assessment of contamination and biomarker responses in two species of herons on the St. Lawrence River. Environ. Monit. Assess. 79: 193-215.

Chase, M.E.; Jones, S.H.; Hennigar, P.; Sowles, J.; Harding, G.C.H.; Freeman, K.; Wells, P.G.; Krahforst, C.; Coombs, K.; Crawford, R.; Pederson, J.; Taylor, D. 2001. Gulfwatch: monitoring spatial and temporal patterns of trace metal and organic contaminants in the Gulf of Maine (1991-1997) with the blue mussel, *Mytilus edulis* L. Mar. Pollut. Bull. 42: 490-505.

Chen, J.Z.; Yauk, C.L.; Hebert, C.; Hebert, P.D.N. 2001. Genetic variation in mitochondrial DNA of North American herring gulls, *Larus argentatus*. J. Great Lakes Res. 27: 199-209.

de March, B.G.E.; de Wit, C.A.; Muir, D.C.G.; Braune, B.M.; Gregor, D.J.; Norstrom, R.J.; Olsson, M.; Skaare, J.U.; Stange, K. 1998. Persistent Organic Pollutants. Pages 183-371 *in* AMAP Assessment Report: Arctic Pollution Issues. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway.

De Vault, D.S.; Hesselberg, R.; Rodgers, P.W.; Feist, T.J. 1996. Contaminant trends in lake trout and walleye from the Laurentian Great Lakes. J. Great Lakes Res. 22: 884-895.

Elliott, J.E.; Norstrom, R.J.; Keith, J.A. 1988. Organochlorines and eggshell thinning in northern gannets (*Sula bassanus*) from eastern Canada, 1968-1984. Environ. Pollut. 52: 81-102.

Elliott, J.E.; Noble, D.G.; Norstrom, R.J.; Whitehead, P.E. 1989. Organochlorine contaminants in seabird eggs from the Pacific coast of Canada, 1971-1986. Environ. Monit. Assess. 12: 67-82.

Elliott, J.E.; Noble, D.G.; Norstrom, R.J.; Whitehead, P.E.; Simon, M.; Pearce, P.A.; Peakall, D.B. 1992a. Patterns and trends of organic contaminants in Canadian seabird eggs, 1968-90. Pages 181-194 *in* C.H. Walker and D.R. Livingstone (eds.), Persistent Pollutants in Marine Ecosystems. Pergamon Press, Oxford, Great Britain.

Elliott, J.E.; Scheuhammer, A.M.; Leighton, F.A.; Pearce, P.A. 1992b. Heavy metal and metallothionein concentrations in Atlantic Canadian seabirds. Arch. Environ. Contam. Toxicol. 22: 63-73.

Elliott, J.E.; Shutt, L. 1993. Monitoring organochlorines in blood of sharp-shinned hawks (*Accipiter striatus*) migrating through the Great Lakes. Environ. Toxicol. Chem. 12: 241-250.

Elliott, J.E.; Whitehead, P.E.; Martin, P.A.; Bellward, G.D.; Norstrom, R.J. 1996. Persistent pulp mill pollutants in wildlife. Pages 297-314 in M.R. Servos, K.R. Munkittrick, J.H. Carey and G.J. Van Der Kraak (eds.), Environmental Fate and Effects of Bleached Kraft Mill Effluents. St. Lucie Press, Delray Beach, FL.

Elliott, J.E.; Machmer, M.M.; Henny, C.J.; Wilson, L.K.; Norstrom, R.J. 1998. Contaminants in ospreys from the Pacific Northwest: I. Trends and patterns in polychlorinated dibenzo-*p*-dioxins and -dibenzofurans in eggs and plasma. Arch. Environ. Contam. Toxicol. 35: 620-631.

Elliott, J.E.; Wilson, L.K.; Henny, C.J.; Machmer, M.M. 2000. Contaminants in osprey from the Pacific Northwest: II. Patterns and trends in organochlorine pesticides, polychlorinated biphenyls and mercury in eggs and plasma. Arch. Environ. Contam. Toxicol. 38: 93-106.

Elliott, J.E.; Harris, M.L.; Wilson, L.K.; Whitehead, P.E.; Norstrom, R.J. 2001. Monitoring temporal and spatial trends in polychlorinated dibenzo-*p*-dioxins (PCDDs) and dibenzofurans (PCDFs) in eggs of great blue heron (*Ardea herodias*) on the coast of British Columbia, Canada, 1983-1998. Ambio 30: 416-428.

Environment Canada. 1993. Toxic Contaminants in the Environment. Persistent Organochlorines. SOE Environmental Indicators Bulletin No. 93-1. 5 pp.

Environment Canada. 2000. Ecosystem Health Status and Trends Monitoring and Reporting System. Report prepared by Environment Canada's Environmental Quality Branch for consideration by the Ecosystem Health Committee of Environment Canada. October 17, 2000. 28 pp.

Environment Canada. 2003. Environment Canada's Fish and Wildlife Effects and Exposure Study. Great Lakes Fact Sheet. Environment Canada, Ontario Region. (In prep.)

Ewins, P.J.; Weseloh, D.V.; Mineau, P. 1992. Geographical distribution of contaminants and productivity measures of herring gulls in the Great Lakes: Lake Huron 1980. J. Great Lakes Res. 18: 316-330.

Ewins, P.J.; Postupalsky, S.; Hughes, K.D.; Weseloh, D.V. 1999. Organochlorine contaminant residues and shell thickness of eggs from known-age female ospreys (*Pandion haliaetus*) in Michigan during the 1980s. Environ. Pollut. 104: 295-304.

Falconer, R.L.; Bidleman, T.F.; Gregor, D.J. 1995. Air-water gas exchange and evidence for metabolism of hexachlorocyclohexanes in Resolute Bay, N.W.T. Sci. Total Environ. 160/161: 65-74.

Fimreite, N. 1979. Accumulation and effects of mercury on birds. Pages 601-627 *in* J.O. Nriagu, (ed.), The Biochemistry of Mercury in the Environment. Elsevier, Amsterdam.

Fox, G.A. 2001. Wildlife as sentinels of human health effects in the Great Lakes-St. Lawrence basin. Environ. Health Perspect. 109: 853-861.

Fox, G.A.; Trudeau, S.; Won, H.; Grasman, K.A. 1998. Monitoring the elimination of persistent toxic substances from the Great Lakes: chemical and physiological evidence from adult herring gulls. Environ. Monit. Assess. 53: 147-168.

Fraser, A.S.; Hodgson, K. 1995. Outline of an environmental information system. Environ. Monit. Assess. 36: 207-215.

Gilbertson, M. 1974. Pollutants in breeding herring gulls in the lower Great Lakes. Can. Field-Nat. 88: 273-280.

Gilbertson, M. 1975. A Great Lakes tragedy. Nature Canada 4: 22-25.

Gilbertson, M. 2001. Canadian Wildlife Service's Herring Gull Monitoring Program: importance to the development of environmental policy on organohalogens. Environ. Rev. 9: 261-267.

Gilbertson, M.; Hale, R. 1974a. Early embryonic mortality in a herring gull colony in Lake Ontario. Can. Field-Nat. 88: 354-356.

Gilbertson, M.; Hale, R. 1974b. Characteristics of the breeding failure of a colony of herring gulls on Lake Ontario. Can. Field-Nat. 88: 356-358.

Gilbertson, M.; Elliott, J.E.; Peakall, D.B. 1987. Seabirds as indicators of marine pollution. Pages 231-248 *in* A.W. Diamond and F.L. Fillion (eds.), The Value of Birds. International Council for Bird Preservation (ICBP) Tech. Publ. No. 6. Cambridge.

Gilman, A.P.; Fox, G.A.; Peakall, D.B.; Teeple, S.M.; Carroll, T.R.; Haymes, G.T. 1977. Reproductive parameters and egg contaminant levels of Great Lakes herring gulls. J. Wildl. Manage. 41: 458-468.

Harding, L.E. 1992. Measures of marine environmental quality. Mar. Pollut. Bull. 25: 23-27.

Harris, M.L.; Elliott, J.E.; Wilson, L.K.; Butler, R.W. 2003a. Reproductive success and chlorinated hydrocarbon contamination of resident great blue herons (*Ardea herodias*) from coastal British Columbia, Canada, 1977 to 1998. Environ. Pollut. 121: 207-227.

Harris, M.L.; Wilson, L.K.; Norstrom, R.J.; Elliott, J.E. 2003b. Egg concentrations of polychlorinated dibenzo-*p*-dioxins and dibenzofurans in double-crested (*Phalacrocorax auritus*) and pelagic (*Phalacrocorax pelagicus*) cororants from the Strait of Georgia, Canada, 1973 to 1998. Environ. Sci. Technol. (in press)

Hebert, C.E. 1998. Winter severity affects migration and contaminant accumulation in northern Great Lakes herring gulls. Ecol. Appl. 8: 669-679.

Hebert, C.E.; Norstrom, R.J.; Simon, M.; Braune, B.M.; Weseloh, D.V.; Macdonald, C.R. 1994. Temporal trends and sources of PCDDs and PCDFs in the Great Lakes: herring gull egg monitoring, 1991-1991. Environ. Sci. Technol. 28: 1266-1277.

Hebert, C.E.; Norstrom, R.J.; Weseloh, D.V. 1999a. A quarter century of environmental surveillance: The Canadian Wildlife Service's Great Lakes Herring Gull Monitoring Program. Environ. Rev. 7: 147-166.

Hebert, C.E.; Shutt, J.L.; Hobson, K.A.; Weseloh, D.V.C. 1999b. Spatial and temporal differences in the diet of Great Lakes herring gulls (*Larus argentatus*): evidence from stable isotope analysis. Can. J. Fish. Aquat. Sci. 56: 323-338.

Hebert, C.E., Hobson, K.A. Shutt, J.L. 2000. Changes in food web structure affect rate of PCB decline in herring gull (*Larus argentatus*) eggs. Environ. Sci.Technol. 34: 1609-1614.

Hebert, C.E.; Weseloh, D.V. Assessing temporal trends in contaminants from long-term avian monitoring programs: the influence of sampling frequency. Ecotoxicol. (in press)

Hesselberg, R.J.; Gannon, J.E. 1995. Contaminant trends in Great Lakes fish. Pages 242-244 *in* E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran and M.J. Mac (eds.), Our Living Resources: A Report to the Nation on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. U.S. Dept. of the Interior, National Biological Service, Washington, DC.

ICES (International Council for the Exploration of the Sea). 2002. Report of the ICES/AMAP Study Group for the Assessment of AMAP POPs and Heavy Metals Data. Advisory Committee on the Marine Environment. ICES CM 2002/ACME:01, Ref. E. Copenhagen, Denmark. 27 pp.

Jarman, W.M.; Simon, M.; Norstrom, R.J.; Burns, S.A.; Bacon, C.A.; Simoneit, B.R.T.; Risebrough, R.W. 1992. Global distribution of *tris*(4-chlorophenyl)methanol in high trophic level birds and mammals. Environ. Sci. Technol. 26: 1770-1774.

Jermyn, K.; Pekarik, C.; Havelka, T.; Barrett, G.; Weseloh, D.V. 2002. An atlas of contaminants in the eggs of fish-eating colonial waterbirds of the Great Lakes (1998-2001). Volume I. Accounts by location. Volume II. Accounts by compound. Unpublished report to CWS, Downsview.

Leonzio, C.; Massi, A. 1989. Metal biomonitoring in bird eggs: a critical experiment. Bull. Environ. Contam. Toxicol. 43: 402-406.

Letcher, R.J.; Norstrom, R.J.; Bergman, C. 1995. Geographical distribution of $MeSO_2$-PCB and -DDE metabolites in pooled polar bear (*Ursus maritimus*) adipose tissue from western hemisphere arctic and subarctic regions. Sci. Total Environ. 160,161: 409-420.

Letcher, R.J.; Norstrom, R.J.; Muir, D.C.G. 1998. Biotransformation versus bioaccumulation: Sources of methyl sulfone PCB and 4,4'-DDE metabolites in the polar bear food chain. Environ. Sci. Technol. 32: 1656-1661.

Lewis, S.A.; Furness, R.W. 1993. The role of eggs in mercury excretion by quail *Coturnix coturnix* and the implications for monitoring mercury pollution by analysis of feathers. Ecotoxicol. 2: 55-64.

Lindell, M.J.; Bemle, G.; Broberg, O.; Larsson, P. 2001. Monitoring of persistent organic pollutants (POPs): examples from Lake Vattern, Sweden. Ambio 30: 545-551.

Kawano, M.; Inoue, T.; Wada, T.; Hidaka, H.; Tatsukawa, R. 1988. Bioconcentration and residue patterns of chlordane compounds in marine animals: invertebrates, fish, mammals and seabirds. Environ. Sci. Technol. 22: 792-797.

Koster, M.D.; Ryckman, D.P.; Weseloh, D.V.; Struger, J. 1996. Mercury levels in Great Lakes herring gull (*Larus argentatus*) eggs, 1972-1992. Environ. Pollut. 93: 261-270.

Macdonald, R.W.; Barrie, L.A.; Bidleman, T.F.; Diamond, M.L.; Gregor, D.J.; Semkin, R.G.; Strachan, W.M.J.; Li, Y.F.; Wania, F.; Alaee, M.; Alexeeva, L.B.; Backus, S.M.; Bailey, R.; Bewers, J.M.; Gobeil, C.; Halsall, C.J.; Harner, T.; Hoff, J.T.; Jantunen, L.M.M.; Lockhart, W.L.; Mackay, D.; Muir, D.C.G.; Pudykiewicz, J.; Reimer, K.J.; Smith, J.N.; Stern, G.A.; Schroeder, W.H.; Wagemann, R.; Yunker, M.B. 2000. Contaminants in the Canadian Arctic: 5 years of progress in understanding sources, occurrence and pathways. Sci. Total Environ. 254: 93-234.

McBride, G.B.; Loftis, J.C.; Adkins, N.C. 1993. What do significance tests really tell us about the environment? Environ. Manage. 17: 423-432.

Mineau, P.; Fox, G.A.; Norstrom, R.J.; Weseloh, D.V.; Hallett, D.J.; Ellenton, J.A. 1984. Using the herring gull to monitor levels and effects of organochlorine contamination in the Canadian Great Lakes. Pages 425-452 *in* J.O. Nriagu and M.S. Simmons (eds.), Toxic Contaminants in the Great Lakes. John Wiley & Sons, New York.

Moisey, J.; Fisk, A.T.; Hobson, K.A.; Norstrom, R.J. 2001a. Hexachlorocyclohexane (HCH) isomers and chiral signatures of α-HCH in the arctic marine food web of the Northwater Polynya. Environ. Sci. Technol. 35: 1920-1927.

Moisey, J.; Simon, M.; Wakeford, B.; Weseloh, D.V.; Norstrom, R.J. 2001b. Spatial and temporal trends of polybrominated diphenyl ethers in Great Lakes herring gull eggs 1980-2001. Second International Workshop on Brominated Flame Retardants, Stockholm, Sweden.

National Institute of Environmental Health Sciences. 2001. Methodologies for community health assessment in Areas of Concern. Environ. Health Perspect. 109 (Suppl. 6): 811-908.

Nettleship, D.N.; Peakall, D.B. 1987. Organochlorine residue levels in three high arctic species of colonially-breeding seabirds from Prince Leopold Island. Mar. Pollut. Bull. 18: 434-438.

Neugebauer, E.A.; Sans Cartier, G.L.; Wakeford, B.J. 2000. Methods for the determination of metals in wildlife tissues using various atomic absorption spectrophotometry techniques. Tech Rep Ser No 337. Canadian Wildlife Service, Ottawa.

Nicholson, M.D.; Fryer, R.J. 1992. The statistical power of monitoring programmes. Mar. Pollut. Bull. 24: 146-149.

Noble, D.G. 1990. Contaminants in Canadian seabirds. SOE Report No. 90-2. Environment Canada, Ottawa. 75 pp.

Noble, D.G.; Elliott, J.E. 1986. Environmental contaminants in Canadian seabirds, 1968-1984: trends and effects. Tech Rep Ser No 13. Canadian Wildlife Service, Ottawa. 275 pp.

Noble, D.G.; Elliott, J.E. 1990. Levels of contaminants in Canadian raptors, 1966 to 1988; effects and temporal trends. Can. Fld.-Nat. 104: 222-243.

Noble, D.G.; Elliott, J.E.; Shutt, J.L. 1993. Environmental contaminants in Canadian raptors, 1965-1989. Tech Rep Ser No 91. Canadian Wildlife Service, Ottawa. 225 pp.

Norstrom, R.J. 1988. Bioaccumulation of polychlorinated biphenyls in Canadian wildlife. Pages 85-100 *in* J-P. Crine (ed.), Hazards, Decontamination, and Replacement of PCBs. Plenum Publishing.

Norstrom, R. 2001. Effects and trends of POPs on polar bears. Pages 215-226 *in* S. Kalhok (ed.), Synopsis of Research Conducted Under the 2000-2001 Northern Contaminants Program. Indian and Northern Affairs Canada, Ottawa.

Norstrom, R.J.; Schweinsberg, R.E.; Collins, B.T. 1986. Heavy metals and essential elements in livers of the polar bear (*Ursus maritimus*) in the Canadian Arctic. Sci. Total Environ. 48: 195-212.

Norstrom, R.J.; Muir, D.C.G. 1994. Chlorinated hydrocarbon contaminants in arctic marine mammals. Sci. Total Environ. 154: 107-128.

Norstrom, R.J.; Belikov, S.E.; Born, E.W.; Garner, G.W.; Malone, B.; Olpinski, S.; Ramsay, M.A.; Schliebe, S.; Stirling, I.; Stishov, M.S.; Taylor, M.K.; Wiig, O. 1998. Chlorinated hydrocarbon contaminants in polar bears from eastern Russia, North America, Greenland and Svalbard: biomonitoring of Arctic pollution. Arch. Environ. Contam. Toxicol. 35: 354-367.

Norstrom, R.J.; Simon, M.; Moisey, J.; Wakeford, B.; Weseloh, D.V. 2002. Geographical distribution (2000) and temporal trends (1981 to 2000) of brominated diphenyl ethers in Great Lakes herring gull eggs. Environ. Sci. Technol. 36: 4783-4789.

Olsson, M. 1995. Ecological effects of airborne contaminants in Arctic aquatic ecosystems: a discussion of methodological approaches. Sci. Total Environ. 160/161: 619-630.

Olsson, M.; Reutergardh, L. 1986. DDT and PCB pollution trends in the Swedish aquatic environment. Ambio 15: 103-109.

Parr, T.W.; Ferretti, M.; Simpson, I.C.; Forsius, M.; Kovacs-Lang, E. 2002. Towards a long-term integrated monitoring programme in Europe: network design in theory and practice. Environ. Monit. Assess. 78: 253-290.

Peakall, D.B.; Noble, D.G.; Elliott, J.E.; Somers, J.D.; Erickson, G. 1990. Environmental contaminants in Canadian peregrine falcons, Falco peregrinus: a toxicological assessment. Can. Fld.-Nat. 104: 244-254.

Pearce, P.A.; Elliott, J.E.; Peakall, D.B.; Norstrom, R.J. 1989. Organochlorine contaminants in eggs of seabirds in the Northwest Atlantic, 1968-1984. Environ. Pollut. 56: 217-235.

Pekarik, C.; Weseloh, D.V. 1998. Organochlorine contaminants in herring gull eggs from the Great Lakes, 1974-1995: change point regression analysis and short-term regression. Environ. Monit. Assess. 53: 77-115.

Pekarik, C.; Weseloh, D.V.; Barrett, G.C.; Simon, M.; Bishop, C.A.; Pettit, K.E. 1998. An atlas of contaminants in the eggs of fish-eating colonial birds of the Great Lakes (1993-1997): Vols I and II. Canadian Wildlife Service, Technical Report Series, No.321.

Pettit, K.E.; Bishop, C.A.; Weseloh, D.V.; Norstrom, R.J. 1994. An atlas of contaminants in eggs of colonial fish-eating birds of the Great Lakes (1989-1992): Vols I and II. Canadian Wildlife Service, Technical Report Series, No.193.

Ryckman, D.P., Weseloh, D.V. and Bishop, C.A. 2000. Contaminants in herring gull eggs from the Great Lakes: 25 years of monitoring levels and effects. Great Lakes Fact Sheet, Environment Canada, Burlington, Ont. www.on.ec.gc.ca/wildlife/factsheets/fs_herring_gulls-e.html

Sandau, C.D.; Meerts, I.T.M.; Letcher, R.J.; McAlees, A.J.; Chittim, B.; Brouwer, A.; Norstrom, R.J. 2000. Identification of 4-hydroxy-heptachlorostyrene in polar bear plasma and its binding affinity to transthyretin: a metabolite of octachlorostyrene? Environ. Sci. Technol. 18: 3871-3877.

Sell, J.L. 1975. Cadmium and the laying hen: apparent absorption, tissue distribution and virtual absence of transfer into eggs. Poultry Sci. 54: 1674-1678.

Shampine, W.J. 1993. Quality assurance and quality control in monitoring programs. Environ. Monit. Assess. 36: 142-151.

Simon, M.; Wakeford, B.J. 2000. Multiresidue method for the determination of polychlorinated dibenzo-*p*-dioxins, polychlorinated dibenzofurans and non-ortho substituted polychlorinated biphenyls in wildlife tissue by HRGC/HRMS. Technical Report Series No. 336E. Canadian Wildlife Service, Ottawa. 41 pp.

Smith, D.W. 1995a. Current and near future trends of PCBs in the Great Lakes. Report prepared for the PCB panel of the Chemical Manufacturers Association. Washington, D.C.

Smith, D.W. 1995b. Are PCBs in the Great Lakes reaching a new equilibrium? Environ. Sci. Technol. 29: 42A-46A.

Smith, D.W. 1995c. Synchronous response of hydrophobic chemicals in Herring Gull eggs from the Great Lakes. Environ. Sci. Technol. 29: 740-750.

Smith, D.W. 2000. Analysis of rates of decline of PCBs in different Lake Superior media. J. Great Lakes Res. 26: 152-163.

Stow, C.A.; Carpenter, S.R.; Webster, K.E.; Frost, T.M. 1998. Long-term environmental monitoring: some perspectives from lakes. Ecol. Appl. 8: 269-276.

Struger, J.; Weseloh, D.V.; Hallett, D.J.; Mineau, P. 1985. Organochlorine contaminants in herring gull eggs from the Detroit and Niagara Rivers and Saginaw Bay (1978-1982): contaminant discriminants. J. Great Lakes Res. 11: 223-230.

Suns, K.R.; Hitchin, G.G.; Toner, D. 1993. Spatial and temporal trends of organochlorine contaminants in spottail shiners from selected sites in the Great Lakes (1975-1990). J. Great Lakes Res. 19: 703-714.

Tanabe, S. 1988. PCB problems in the future: foresight from current knowledge. Environ. Pollut. 50: 2-28.

Tanabe, S.; Watanabe, S.; Kan, H.; Tatsukawa, R. 1988. Capacity and mode of PCB metabolism in small cetaceans. Mar. Mammal Sci. 4: 103-124.

Ter Keurs, W.J.; Meelis, E. 1986. Monitoring the biotic aspects of our environment as a policy instrument. Environ. Monit. Assess. 7: 161-168.

Tittlemier, S.A., Simon, M., Jarman, W.M., Elliott, J.E. and R.J. Norstrom. 1999. Identification of a novel $C_{10}H_6N_2Br_4Cl_2$ heterocyclic compound in seabird eggs. A bioaccumulating marine natural product? Environ. Sci. Technol. 33: 26-33.

Turle, R.; Norstrom, R.J.; Won, H.T. 1988. Quality assurance as applied to long-term monitoring of chemical residues and specimen banking. Pages 171-183 *in* S.A. Wise, R. Zeisler and G.M. Goldstein (eds.), Progress in Environmental Specimen Banking. National Bureau of Standards Special Publication 740. U.S. Government Printing Office, Washington DC.

van den Brink, N.W.; van Franeker, J.A.; de Ruiter-Dijkman, E.M. 1998. Fluctuating concentrations of organochlorine pollutants during a breeding season in two Antarctic seabirds: Adélie penguin and southern fulmar. Environ. Toxicol. Chem. 17: 702-709.

Wagemann, R.; Innis, S.; Richard, P.R. 1996. Overview and regional and temporal differences of heavy metals in Arctic whales and ringed seals in the Canadian Arctic. Sci. Total Environ. 186: 41-67.

Wakeford, B.; Turle, R. 1997. In-house reference materials as a means to quality assurance: the Canadian Wildlife Service experience. Pages 205-231 *in* R.E. Clement, L.H. Keith and K.W.M. Siu (eds.), Reference Materials for Environmental Analysis. CRC Press, Inc.

Wania, F.; Mackay, D. 1993. Global fractionation and cold condensation of low volatility organochlorine compounds in polar regions. Ambio 22: 10-18.

Wania, F.; Mackay, D. 1999. Global chemical fate of a-hexachlorocyclohexane. 2. Use of a global distribution model for mass balancing, source apportionment, and trend prediction. Environ. Toxicol. Chem. 18: 1400-1407.

Weseloh, D.V.; Mineau, P.; Hallett, D.J. 1979. Organochlorine contaminants and trends in reproduction in Great Lake herring gulls, 1974-1978. Trans. 44th North Am. Wildl. And Natural Resources Conf., Wildlife Mgmt. Inst., pp. 543-557.

Weseloh, D.V.; Mineau, P.; Struger, J. 1990. Geographical distribution of contaminants and productivity measures of herring gulls in the Great Lakes: Lake Erie and connecting channels 1978/79. Sci. Total Environ. 91: 141-159.

Weseloh, D.V.C.; Ewins, P.J.; Struger, J.; Mineau, P.; Norstrom, R.J. 1994. Geographical distribution of organochlorine contaminants and reproductive parameters in herring gulls on Lake Superior in 1983. Environ. Monitor. Assess. 29: 229-251.

Wiberg, K.; Letcher, R.J.; Sandau, C.D.; Norstrom, R.J.; Tysklind, M.; Bidleman, T.F. 2000. The enantioselective bioaccumulation of chiral chlordane contaminants in the polar bear food chain. Environ. Sci. Technol. 34: 2668-2674.

Won, H.T.; Mulvihill, M.J.; Wakeford, B.J. 2000. Multiresidue methods for the determination of chlorinated pesticides and polychlorinated biphenyls (PCBs) in wildlife tissues by Gas chromatography/Mass spectrometry. Tech Rep Ser No 335. Canadian Wildlife Service, Ottawa.

Yamashita, N.; Tanabe, S.; Ludwig, J.P.; Kurita, H.; Ludwig, M.E.; Tatsukawa, R. 1993. Embryonic abnormalities and organochlorine contamination in double-crested cormorants (*Phalacrocorax auritus*) and Caspian terns (*Hydroprogne caspia*) from the upper Great Lakes in 1988. Environ. Pollut. 79: 163-173.

Zhu, J.P.; Norstrom, R.J. 1994. Identification of polychlorocamphenes (PCCs) in the polar bear (*Ursus maritimus*) food chain. Chemosphere 27: 1923-1935.

Zhu, J.; Norstrom, R.J.; Muir, D.C.G.; Ferron, L.A.; Weber, J.-P.; Dewailly, E. 1995. Persistent chlorinated cyclodiene compounds in Ringed seal, polar bear and human plasma from Northern Quebec, Canada: Identification and concentrations of photoheptachlor. Environ. Sci. Technol. 28: 267-271.

Appendix 1. The CWS Contaminant Monitoring Program Assessment (CCMPA). The database.

Project Summary

This project was initiated to compile information on:

- Canadian and Canadian-U.S. bilateral programs monitoring contaminants in biota; and on an opportunistic basis,
- major international programs monitoring contaminants in avian species;
- Canadian and Canadian-U.S. bilateral programs monitoring population status or other ecological parameters in avian species for which contaminant monitoring data have been collected.

Definition of Monitoring

"Programs with at least three temporal data points for a given sample population."

Purpose of Monitoring

To ensure that wildlife populations and communities are healthy, sustainable and maintained within desired abundances and distribution limits.

CCMPA Assessment

Assessment of CWS contaminant monitoring programs in context of other monitoring programs, (both contaminant and population) as well as current contaminant issues, with respect to:

- monitoring gaps and redundancies with other contaminant monitoring programs;
- relevance to current contaminant issues;

and,

- relation to ecological/population monitoring programs.

Database Description

The compiled data were organized into a searchable database that contains a detailed description of each program and geographic coordinates for each monitoring location. It includes variables such as the program objective, species and tissues sampled, duration, sampling frequency and

spatial distribution, chemicals analyzed, responsible agency and list of publications arising from the program. It also assesses the nature of the program to determine if it constitutes systematic or opportunistic monitoring.

The Contaminant Monitoring Programs database, ccmpa_metadata.mdb, contains 5 tables:

1. Program Descriptions
2. Monitoring Locations
3. Publications
4. Coordinating Program Descriptions
5. Coordinating Program Monitoring Locations

Field Descriptions for Tables within the Database

1. Program Descriptions

This is a summary table containing pertinent information for monitoring programs occurring worldwide:

ProgramID	code of the form 'aa-###' - The two letters refer to a jurisdiction, (AS = Asia, CA = Canada, EU = Europe, IN = International, US = USA) and the 3 digits a sequential numbering scheme.
Program Name	the official name of the program
Program Summary	a short description of the program, including its major objectives
Program Type	a one word description of the nature of the program *Systematic* - a designed monitoring program *Opportunistic* - monitoring using available samples (e.g. using found moribund animals) *Review* - time trend established by reviewing pre-existing work *Retrospective* - using specimen bank or museum material to reanalyze contaminant levels
Program Focus	contaminant or ecological
Agency	the organization running the program
Country	country(ies) participating in the program

Province/Territory	two letter code (also includes 2 letter code for U.S. states)
Geographic Coverage	the range and locations of sampling
Period of Data	the years of coverage of the program
Program Status	completed or ongoing
Primary Taxa	the taxonomic group of primary interest *Bird* *Fish* *Mammal* *Herpetofauna* – amphibians and reptiles *Other* – taxa that are not included in other listed categories *Mixed* – multiple or unspecified taxa
Species	the species sampled
Tissues	the tissues and other matrices sampled
Contaminant type	the main contaminant group (metals, OCs etc.)
Contaminant	the main contaminant (mercury, DDT etc.)
Specific Residues	the residues analyzed
Data Acquisition Methods	how the samples are collected and analyzed
Sampling Frequency	how often are samples collected (monthly, seasonally, annually etc.)
Archiving	are tissues from the program archived for future use
Tissue Bank Location	where are the tissues archived
Variables	what other data are collected
Data Storage	what format is the data stored in
Database Size	how many records are in the database
Access	who has access to the data
Restrictions/Locations	what access restrictions exist

Language	what language is the database in
Comments	any additional information about the database
Contact Name	the person responsible for the database
Phone	if available
Address	if available
Email	if available
Website	if available

2. Monitoring Locations

This table contains data concerning sampling locations.

Program ID	code of the form 'aa-###' - The two letters refer to a jurisdiction, (AS = Asia, CA = Canada, EU = Europe, IN = International, US = USA) and the 3 digits a sequential numbering scheme.
No. of Sites	the number of sites monitored
Location Name	the name of the sampling location
Latitude	latitude of location in decimal degrees
Longitude	longitude of location in decimal degrees

3. Publications

This table lists publications arising out of the monitoring program or describing it.

ProgramID	code of the form 'aa-###' - The two letters refer to a jurisdiction, (AS = Asia, CA = Canada, EU = Europe, IN = International, US = USA) and the 3 digits a sequential numbering scheme.
Program Name	the official name of the program
Author 1	first author
Other Authors	second and subsequent authors
Year	year of publication

Title	article/book title
Journal	title of journal and volume and paging of article
Editors	editors of book/proceedings (if appropriate)
Book Title	title of book/proceedings (if appropriate), with publisher and pagination

4. Coordinating Program Descriptions

These were kept separate from the main table of Program Descriptions because they are umbrella programs that are repositories of information. Field definitions for this table are described above in: "1. Program Descriptions".

5. Coordinating Program Monitoring Locations

These are sampling locations that were identified for Coordinating Programs. Field definitions for this table are described above in: "2. Monitoring Locations".

Notes on summary tables appearing in appendices

- In Table A1-1, A1-2 and A1-4, the "Number of Monitoring Sites" includes only those sites that were given specific geographic coordinates. For some programs with large numbers of associated monitoring sites, latitude and longitude were not readily available for all locations. In those cases, a single centroid entry was made as representative of a larger number of sites contained within a defined polygon (see Appendix 3; Mapping Limitations). Therefore, in some cases, the number of monitoring sites underestimates the actual number of sites sampled.
- CA-016, CA-046 and CA-054 are both contaminant and ecological monitoring programs.
- CA-016, CA-094, CA-103 and CA-104 are collaborative programs conducted by CWS and non-CWS agencies; as such, they appear multiple times in Tables A2-1 to A2-4.
- Tables A1-2 to A1-4 and A2-1 to A2-4 exclude Canadian-U.S. bilateral programs that are led by U.S. agencies (US-006, US-007, and US-046).

Table A1-1. Monitoring programs occurring in Canada for all described taxa (refer to field descriptions for Program Descriptions table), plus major Canadian-U.S. bilateral programs and major international avian programs.

Program Status		Contaminant	Ecological	Total
Ongoing	Number of Programs	54	47	94
	Number of Monitoring Sites	580	654	1208
Completed	Number of Programs	76	20	93
	Number of Monitoring Sites	646	104	742

Table A1-2. Canadian monitoring programs.

Program Status		Contaminant	Ecological	Total
Ongoing	Number of Programs	30	37	65
	Number of Monitoring Sites	386	610	994
Completed	Number of Programs	26	15	40
	Number of Monitoring Sites	170	99	263

Table A1-3. Number of Canadian contaminant monitoring programs by region.

Region		Program Status	Number of Programs *	Number of CWS Programs
Atlantic		Ongoing	7	2
		Completed	7	3
Quebec		Ongoing	7	3
		Completed	5	4
Ontario		Ongoing	9	3
		Completed	11	7
Prairie & Northern	Prairie Provinces	Ongoing	2	0
		Completed	4	3
	NWT & Nunavut	Ongoing	8	1
		Completed	8	3
Pacific & Yukon	British Columbia	Ongoing	5	2
		Completed	4	4
	Yukon	Ongoing	2	0
		Completed	2	2
Multi-regional **		Ongoing	5	2
		Completed	4	4
Total (All Regions Combined)		Ongoing	30	9
		Completed	26	11

* Other Agencies = academic / Canadian Fish Inspection Agency / CWS, DOE / DFO / DIAND / DOE / industry / NGO / provincial and/or territorial governments

** Multi-regional programs are also included under relevant region

Table A1-4. Number of contaminant programs and number of monitoring sites across Canada based on contaminant type.

Contaminant Type	Program Status	Number of Programs	Number of Monitoring Sites
Metals	Ongoing	18	187
	Completed	15	106
Organic Chemicals	Ongoing	25	353
	Completed	23	157
Radionuclides	Ongoing	4	28
	Completed	1	9
Other *	Ongoing	2	15
	Completed	1	1

* Other = stable isotopes

Appendix 2. The CWS Contaminant Monitoring Program Assessment (CCMPA). List of Canadian contaminant monitoring programs in the database.

Table A2-1. List of CWS contaminant monitoring programs.

Program Status	Program ID	Program Name	Period of Data	Agency	Province /Territory
ongoing	CA-001	IJC Great Lakes herring gull contaminant monitoring program	1972-	CWS, DOE	ON
ongoing	CA-008	Contaminants in eggs of fish-eating colonial birds of the Great Lakes	1970-	CWS, DOE	ON
ongoing	CA-012	Contaminants in Arctic seabird eggs	1975-	CWS, DOE	NT
ongoing	CA-016	Population and contaminant trends in Bonaventure Island northern gannets	1967-	CWS, DOE, Prov Québec	QC
ongoing	CA-026	Contaminants in Pacific seabird eggs	1971-	CWS, DOE	BC
ongoing	CA-044	CWS Long Range Transport of Air Pollutants (LRTAP) Biomonitoring Program	1987-	CWS, DOE	ON, NS
ongoing	CA-050	Environmental contaminants in British Columbia great blue herons	1970-	CWS, DOE	BC
ongoing	CA-053	Contaminants in Atlantic seabird eggs	1968-	CWS, DOE	QC, NF, NS, NB, PE
ongoing	CA-105	Quebec heronry census	1991-	CWS, DOE	QC
completed	CA-007	Organochlorine residues in eggs of common snapping turtle in Ontario	1981-1991	CWS, DOE	ON
completed	CA-028	Organochlorines and shell thinning in Ontario hawks	1986-1989	CWS, DOE	ON
completed	CA-029	Contaminants in Pacific northwest ospreys	1991-1997	CWS, DOE	BC
completed	CA-030	Patterns and trends of organochlorines and mercury in Pacific coast bald eagle eggs	1990-1994	CWS, DOE	BC
completed	CA-049	Environmental contaminants in Canadian raptors	1965-1989	CWS, DOE	HQ
completed	CA-051	Contaminant trends in polar bears	1968-1995	CWS, DOE	HQ
completed	CA-052	Environmental contaminants in Canadian peregrine falcons	1965-1987	CWS, DOE	HQ
completed	CA-054	Contaminants and cormorant populations in the Great Lakes	1969-1975	CWS, DOE	ON
completed	CA-062	Organochlorines in migrating sharp-shinned hawks in Ontario	1985-1989	CWS, DOE	ON
completed	CA-103	Southern Ontario bald eagle monitoring project	1983-1999	CWS, DOE, OMNR, NGO	ON
completed	CA-106	Organochlorine residues in American Woodcock	1969-81, 1986, 1988	CWS, DOE	NB, NS, ON, QC

Table A2-2. List of Canadian contaminant monitoring programs – non-CWS agencies.

Program Status	Program ID	Program Name	Period of Data	Agency	Province /Territory
ongoing	CA-002	Long term trends in organochlorine residues in Arctic seal blubber	1972-	DFO	NT
ongoing	CA-010	Great Lakes Fish Contaminants Surveillance Program [GLFCSP]	1977-	DFO	ON
ongoing	CA-011	Organochlorine contaminants in spottail shiners (Notropis hudsonius) from the Great Lakes	1975-	Prov/Terr	ON
ongoing	CA-016	Population and contaminant trends in Bonaventure Island northern gannets	1967-	CWS, DOE, Prov Québec	QC
ongoing	CA-021	Ontario Sport Fish Contaminant Monitoring Program (OSFCMP)	1967-	Prov/Terr	ON
ongoing	CA-032	Contaminants in Yukon big game	1991-	DIAND	YT
ongoing	CA-043	Organochlorine contaminants in beluga whales in the St. Lawrence estuary	1982-	DFO	QC
ongoing	CA-045	Environmental contaminants in caribou in the Northwest Territories	1991-	Prov/Terr	NT
ongoing	CA-046	The Experimental Lakes Area (ELA) Project northwestern Ontario ecosystem database	1969-	DFO	ON
ongoing	CA-048	Contaminants in Arctic belugas	1972-	DFO	
ongoing	CA-072	Heavy metals in Arctic marine mammals	1972-	DFO	NT
ongoing	CA-073	Sources, pathways and levels of contaminants in fish from Yukon waters	1991-	Prov/Terr	YT
ongoing	CA-075	Newfoundland Fisheries Inspection Branch database	1960-	CFA	NF
ongoing	CA-083	Atlantic Region Fish and Fish Products Contaminants Database	1984-	CFA	
ongoing	CA-084	Freshwater Fish Contaminants Database	1970-	DFO	
ongoing	CA-085	National Contaminants Information System (NCIS)	mid 1970s-	DFO	
ongoing	CA-087	PCB and Organochlorine Pesticides Content of Rain, Seawater, Plankton and fish in the southern Gulf of St. Lawrence	1976-	DFO	
ongoing	CA-089	Northern Aquatic Food Chain Contaminants Database	early 1970s-	DIAND	
ongoing	CA-092	New Brunswick Biomonitoring Program	1980-90, ad-hoc since	Prov/Terr	NB

Program Status	Program ID	Program Name	Period of Data	Agency	Province /Territory
ongoing	CA-093	Network for Monitoring Toxic Substances in the Aquatic Environment of the St. Lawrence	1978-	Prov/Terr	QC
ongoing	CA-099	Dioxins and Furans in the British Columbia Environment	1990-	Prov/Terr	BC
ongoing	CA-100	BC Environmental Monitoring System (EMS)	1965-	Prov/Terr	BC
completed	CA-003	Organochlorine residue trends in Sable Island, Nova Scotia grey seal	1972-1994	DFO	NS
completed	CA-020	Organochlorine contaminants in peregrine falcon and its prey at Rankin Inlet, NT	1981-1986 and 1991-1994	Prov/Terr	NT
completed	CA-027	Organochlorine and heavy metal contamination in mink from the Mackenzie Delta	1992-1994	Prov/Terr	NT
completed	CA-033	Organochlorines in Great Lakes fish	1968-1976	Prov/Terr	ON
completed	CA-034	Organochlorines and heavy metals in Ontario loons	1968-1980	Prov/Terr	ON
completed	CA-035	Organochlorines in birds found dead in Ontario	1972-1988	Prov/Terr	ON
completed	CA-037	Contaminants in Bay of Fundy harbor porpoises	1969-1977	academic	NB
completed	CA-041	Radioactivity in Great Lakes fish	1976-1982	DOE	ON
completed	CA-042	Mercury trends in bowhead whale baleen	1971-1990	DFO	
completed	CA-047	Contaminant trends in Canadian Atlantic cod	1977-1985	DFO	
completed	CA-058	Slave River Monitoring Program	1989-1995	DIAND	NT
completed	CA-065	Organochlorines in Canadian Arctic amphipods	1986-1988	DFO	NT
completed	CA-071	Mercury evolution in fishes of the La Grande hydroelectric complex	1978-1988	Industry	QC
completed	CA-074	Organochlorines in Atlantic double-crested cormorants	1971-1975	DOE	NB
completed	CA-096	Manitoba Fish Biomonitoring	1978-1992	Prov/Terr	MB
completed	CA-103	Southern Ontario bald eagle monitoring project	1983-1999	CWS, DOE, OMNR, NGO	ON

Table A2-3. CWS ecological monitoring programs.

Program Status	Program ID	Program Name	Period of Data	Agency	Province /Territory
ongoing	CA-004	Canadian Migratory Game Bird National Harvest Survey (NHS)	1966-	CWS, DOE	
ongoing	CA-005	Canadian Migratory Game Bird Species Composition Survey (SCS)	1966-	CWS, DOE	
ongoing	CA-014	Ontario Forest Bird Monitoring Program (FBMP)	1987-	CWS, DOE	ON
ongoing	CA-015	Census of seabird populations in Gulf of St. Lawrence sanctuaries	1925-	CWS, DOE	QC
ongoing	CA-016	Population and contaminant trends in Bonaventure Island northern gannets	1967-	CWS, DOE, Prov Québec	QC
ongoing	CA-017	Breeding Bird Survey in Canada (BBS)	1966-	CWS, DOE	
ongoing	CA-024	Canadian Seabird Population Monitoring Program - Arctic and Atlantic	1925-	CWS, DOE	
ongoing	CA-025	Maritimes Shorebird Survey	1974-	CWS, DOE	NB, NF, NS, PE
ongoing	CA-036	North American peregrine falcon survey	1970-	CWS, DOE	
ongoing	CA-038	Monitoring thick-billed murre populations in northern Hudson Bay	1972-	CWS, DOE	NT
ongoing	CA-057	Population trends in southern Ontario ducks	1971-	CWS, DOE	ON
ongoing	CA-059	British Columbia waterfowl breeding pair survey	1987-	CWS, DOE	BC
ongoing	CA-060	Southern Yukon waterfowl breeding pair survey	1992-	CWS, DOE	YT
ongoing	CA-069	Migratory game bird population status	1955-	CWS, DOE	
ongoing	CA-076	Breeding biology and habitat of prairie ducks	1980-	CWS, DOE	SK
ongoing	CA-077	Coastal Waterfowl Survey	1966-	CWS, DOE	
ongoing	CA-078	Colonial birds in the maritimes	1960-	CWS, DOE	
ongoing	CA-079	Inventories of colonial waterbirds nesting on the Canadian Great Lakes	1989-	CWS, DOE	ON
ongoing	CA-081	Quebec Seabird Registry	1833-	CWS, DOE	QC
ongoing	CA-082	Whooping Crane Migratory Records – Saskatchewan	1957-	CWS, DOE	SK

Program Status	Program ID	Program Name	Period of Data	Agency	Province /Territory
ongoing	CA-091	Avian Census Plots	1937-	CWS, DOE	
ongoing	CA-094	Quebec Waterfowl Inventory	1982-	CWS, DOE, Prov/Terr/State, USFWS, USGS, NGO	QC
ongoing	CA-104	Southern Ontario bald eagle monitoring project	1983-	CWS, DOE, OMNR, NGO	ON
completed	CA-018	Bird abundance and distribution at McKinley Bay and Hutchinson Bay, NT	1981-1985, 1990-1993	CWS, DOE	NT
completed	CA-019	Distribution and abundance of birds on western Victoria Island	1992-1994	CWS, DOE	NT
completed	CA-022	Quebec heronry census	1977-1986	CWS, DOE	QC
completed	CA-023	Red-throated loon populations on Tuktoyaktuk Peninsula, NT	1985-1989	CWS, DOE	NT
completed	CA-031	Aerial survey of breeding waterfowl - Atlantic Region	1985-1990	CWS, DOE	NB, NS, NF, PE
completed	CA-039	Waterfowl survey in Labrador-Ungava	1970-1972	CWS, DOE	NF, QC
completed	CA-054	Contaminants and cormorant populations in the Great Lakes	1969-1975	CWS, DOE	ON
completed	CA-055	Population and productivity changes in the Lake Ontario double-crested cormorant	1950-1982	CWS, DOE	ON
completed	CA-067	Seals in the eastern Beaufort Sea 1974-1979	1974-1979	CWS, DOE	YT, NT
completed	CA-068	Spring migration of waterfowl in the Yellowknife-Thor Lake area, Northwest Territories	1986-1988	CWS, DOE	NT
completed	CA-070	Northern Ontario waterfowl database	1980-1989	CWS, DOE	ON
completed	CA-080	Prairie migratory birds	1965-1986	CWS, DOE	

Table A2-4. Canadian ecological monitoring programs – non-CWS agencies.

Program Status	Program ID	Program Name	Period of Data	Agency	Province /Territory
ongoing	CA-009	Ontario Herpetofaunal Summary (OHS)	1984-	Prov/Terr	ON
ongoing	CA-013	National Ecological Monitoring and Assessment (EMAN)	1994-	DOE	
ongoing	CA-016	Population and contaminant trends in Bonaventure Island northern gannets	1967-	CWS, DOE, Prov Québec	QC
ongoing	CA-040	Lake Ontario long term biomonitoring program	1981-	DFO	ON
ongoing	CA046	The Experimental Lakes Area (ELA) Project northwestern Ontario ecosystem Database	1969-	DFO	ON
ongoing	CA-056	DFO National LRTAP Biomonitoring Program	1987-	DFO	
ongoing	CA-061	Project Feeder Watch (PFW)	1976-	NGO	
ongoing	CA-064	Canadian Migration Monitoring Network - Intensive surveys	1961-	NGO	
ongoing	CA-066	Forest Insect and Disease Survey	1936-	NRCan	
ongoing	CA-088	Scotia-Fundy Marine Mammals Database	1960s-	DFO	
ongoing	CA-090	Northern Canada Pollen Data	not applicable	NRCan	
ongoing	CA-094	Quebec Waterfowl Inventory	1982-	CWS, DOE, Prov/Terr/State, USFWS, USGS, NGO	QC
ongoing	CA-095	Polar Bear Research Data	1963-1996	Prov/Terr	ON
ongoing	CA-097	British Columbia Seabird Colony File	1968-	Prov/Terr	BC
ongoing	CA-101	Northwest Territories caribou data	1989-	Prov/Terr	NT
ongoing	CA-102	Harbour seal and sea lion census database	1892-	DFO	BC
completed	CA-006	Acid Rain National Early Warning System (ARNEWS)	1984-?	NRCan	
completed	CA-086	Northern Fur Seal Specimen and Census Database	1958-1974	DFO	
completed	CA-098	BC Coastal Waterbirds	1960-1980	Prov/Terr	BC

Appendix 3. The CWS Contaminant Monitoring Program Assessment (CCMPA). The mapping program.

What is included in the Installation and Operation.pdf file?

- Installation procedure for CWS Monitor application
- Basic operation of ArcView software for more complex queries

How does this program work?

The mapping program has 3 basic components that work together interactively. The following steps indicate the sequence of communication between the various components.

1. Mapping of Monitoring Programs window - criteria are selected
2. Access Database - records are queried
3. ArcView GIS mapping software - map is generated and data are displayed

Mapping of the Monitoring Sites

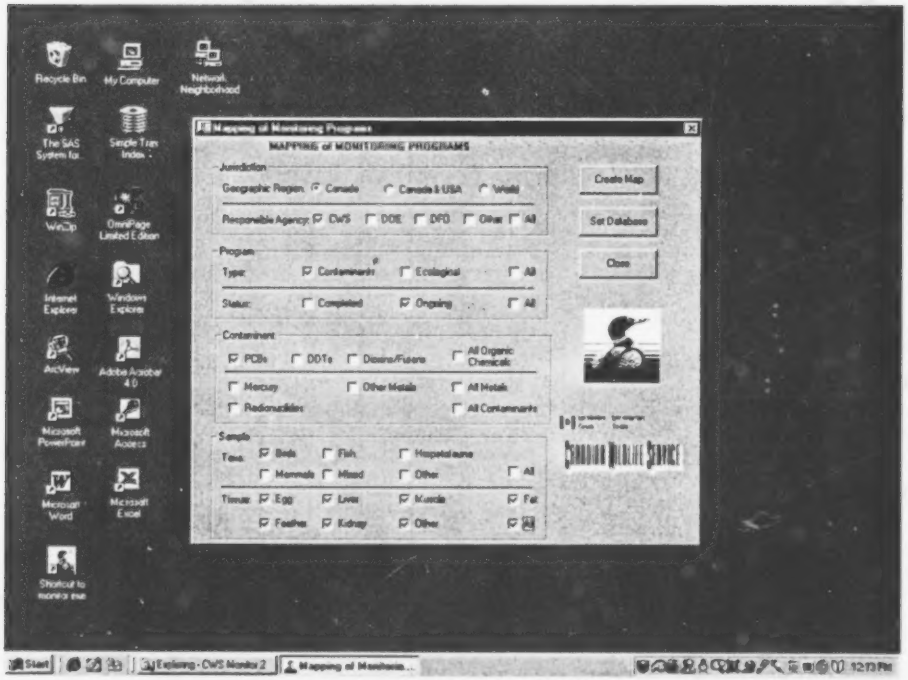
Each monitoring site within the database has been assigned a latitude and longitude. These locations can be mapped using ArcView GIS software and the custom "user friendly" interface provided.

The interface with GIS allows creation of maps of monitoring sites based on any selection of:

1. *Jurisdiction – Geographic Region*: Canada, Canada & USA, or World
2. *Responsible Agency*: CWS, DOE, DFO, Other Agency, or All Agencies
3. *Program Type*: Contaminant, Ecological, or All Programs
4. *Program Status*: Completed, Ongoing, or All Programs
5. *Contaminant*: i. PCBs, DDT, Dioxins/Furans, All Organic Chemicals, Mercury, Other
   ii. Metals, All Metals, Radionuclides, or All Contaminants
6. *Sample Taxa*: Birds, Fish, Mammals, Herpetofauna, Mixed, Other, or All Taxa
7. *Sample Tissue*: Egg, Feather, Liver, Kidney, Muscle, Fat, Other, or All Tissues

These maps may be superimposed on geographical maps showing rivers, lakes, major cities, political boundaries, ecozones etc. as desired.

Example:	*Category*	*Criteria*
	Geographic Region	Canada
	Responsible Agency	CWS
	Program Type	Contaminants
	Program Status	Ongoing
	Contaminant	PCBs
	Sample Taxa	Birds
	Sample Tissue	All



This is the Mapping of Monitoring Programs window showing activation of example criteria. The map and associated tables generated in the ArcView project will reflect the criteria set in the Mapping of Monitoring Programs window.

Mapping Limitations

It should be taken into account that as a result of mapping limitations a number of programs and associated monitoring locations may be misrepresented by the ArcView display. A number of monitoring sites were logistically difficult to display because of data restrictions and/or mapping limitations. Nevertheless, these were still incorporated into the program so that all available data are captured. These locations were identified as "polygons" instead of "points" in the database.

Accessing data

Attributes (information) for a particular feature (record) on the map created can be accessed by clicking on that feature with the mouse. ArcView will then produce an Identify Results pop-up window that displays the attribute data.

What's on the CD?

The CD in this back pocket contains:

- *Readme.pdf* * - file describing contents of CD
- *ccmpa_metadata.mdb* - Microsoft Access 95 database containing CCMPA metadata
- *inst_ccmpa.exe* - CCMPA Mapping Application (requires Microsoft Access 95 and ArcView 3.2 GIS software)
- *Installation and Operation.pdf* * - CCMPA Mapping Application installation and operation procedure
- *Monitoring Assessment.pdf* - this report

* in both English and French

Installation and Operation Procedure for inst_ccmpa.exe

Program Requirements

ArcView 3.2 GIS and Microsoft Access 95 software are required to install and operate inst_ccmpa.exe.

What is included in this document?

(i) Installation procedure for the inst_ccmpa.exe application – Steps 1 to 3

(ii) Basic operation of ArcView software for more complex queries – Steps 4 to 6

How does the inst_ccmpa.exe program work?

The inst_ccmpa.exe application has 3 basic components that work together interactively. The following flowchart demonstrates the direction of communication between the various components.

Mapping of Monitoring Programs window
criteria are selected

↓

Access Database - ccmpa_gis.mdb
records are queried

↓

ArcView GIS mapping software
map is generated & data are displayed

Program Installation

Step 1: Install the Mapping of Monitoring Programs application

Load the CCMPA CD into your disc drive. In Windows Explorer, locate the inst_ccmpa.exe application and left click 2x. This will begin the installation process.

The following are a series of windows that should appear consecutively. Select "Next >" to continue and "Finish >" to complete the installation.

Note: Select "Cancel" to exit the installation procedure.

Projet canadien d'évaluation de la surveillance des contaminants (CCMPA)

Contenu du disque compact :

1. **Lisez-moi.pdf**
   - Exposé du contenu du disque compact.

2. **ccmpa_metadata.mdb**[1]
   - Base de données Microsoft Access 95 contenant les métadonnées du PCESC.
   - Ouvrir ce fichier pour avoir accès à l'ensemble complet des données, notamment les tableaux suivants[2] :
     i. Description des programmes
     ii. Lieux de surveillance
     iii. Publications
     iv. Coordination de la description des programmes
     v. Coordination des lieux de surveillance

[1] Ce fichier a été joint à l'intention des utilisateurs qui n'ont pas le logiciel de SIG ArcView 3.2.
[2] Consulter « Monitoring Assessment.doc » pour obtenir une description détaillée des tableaux.

3. **inst_ccmpa.exe**
   - Application cartographique du PCESC qui comprend une interface graphique personnalisée et conviviale dans laquelle des interrogations peuvent être effectuées pour permettre la cartographie de la base de données à l'aide du logiciel de SIG ArcView 3.2.
   - Cliquer deux fois sur inst_ccmpa.exe pour commencer la procédure d'installation.
   - Ce programme comprend :
     i. L'interface graphique personnalisée et conviviale de Mapping of Monitoring Programs;
     ii. La base de données de cartographie – ccmpa_gis.mdb (on interroge cette base de données à des fins de cartographie);
     iii. Les fichiers de projet du logiciel ArcView 3.2 afférents du PCESC (et non le logiciel ArcView 3.2 même).

4. **Procédure d'installation et d'utilisation.pdf**
   - Directives détaillées pour l'installation de l'application du PCESC (inst_ccmpa.exe) et sur le fonctionnement de base du logiciel de SIG ArcView 3.2.

5. **Monitoring Assessment.pdf**
   - Copie du rapport technique du SCF : « An Assessment of Canadian Wildlife Service Contaminant Monitoring Programs ».

Procédure d'installation et d'utilisation de inst_ccmpa.exe

Exigences du programme

Les logiciels ArcView 3.2 GIS et Microsoft Access 95 sont nécessaires pour installer et utiliser inst_ccmpa.exe.

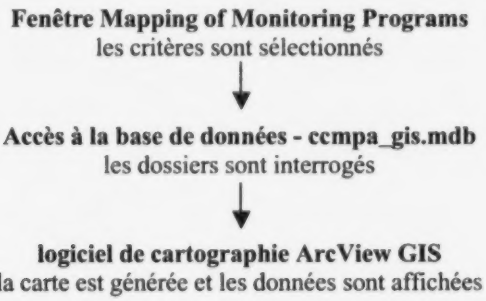
Que contient ce document?

(i) La procédure d'installation de l'application inst_ccmpa.exe : Étapes 1 à 3;

(ii) Les principes d'utilisation de base du logiciel ArcView pour les requêtes plus complexes: Étapes 4 à 6.

Comment fonctionne le programme inst_ccmpa.exe?

L'application inst_ccmpa.exe comporte trois composants fonctionnant conjointement de façon interactive. L'organigramme suivant indique comment l'information est acheminée d'un composant à l'autre.


Fenêtre Mapping of Monitoring Programs
les critères sont sélectionnés
Accès à la base de données - ccmpa_gis.mdb
les dossiers sont interrogés
logiciel de cartographie ArcView GIS
la carte est générée et les données sont affichées

Installation du programme

1re étape : Installer l'application Mapping of Monitoring Programs

Insérez le disque compact CCMPA dans votre lecteur de disques compacts. Dans l'explorateur Windows, repérez l'application inst_ccmpa.exe et cliquez deux fois à l'aide du bouton gauche de la souris pour lancer le processus d'installation.

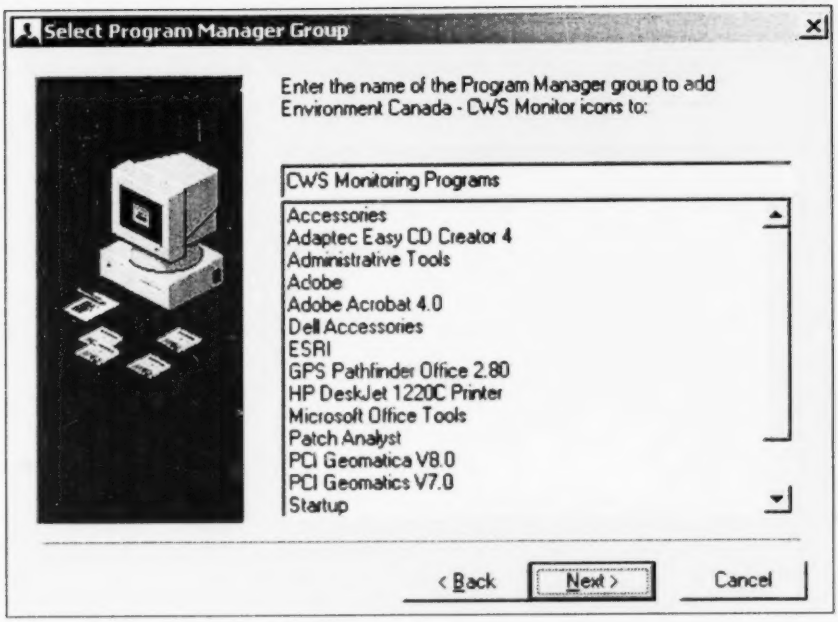
Les images suivantes représentent les fenêtres qui devraient s'afficher l'une après l'autre. Choisissez « Next » pour continuer et « Finish » pour terminer l'installation.

Remarque : Choisissez « Cancel » pour quitter la procédure d'installation.

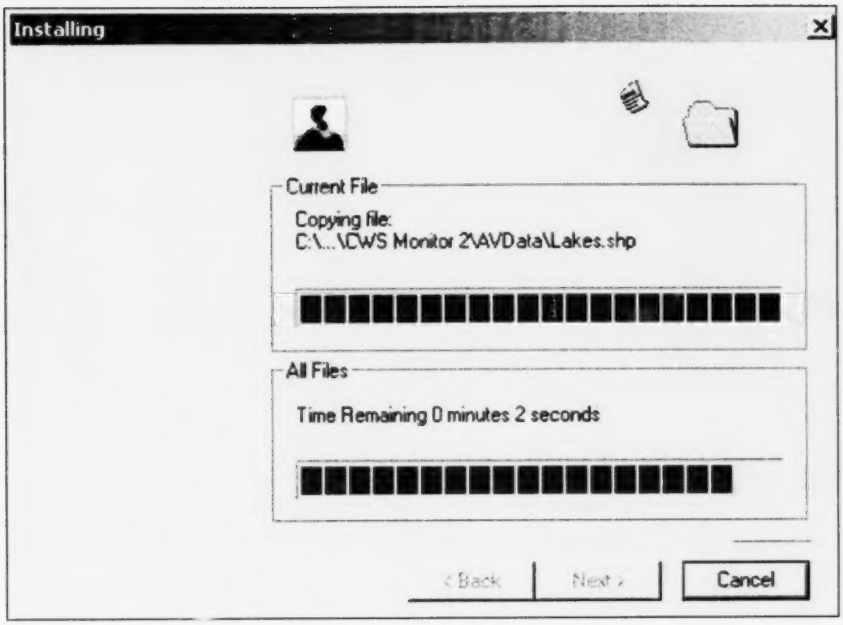
Welcome
Welcome to Environment Canada - CWS Monitor Setup program. This program will install Environment Canada - CWS Monitor on your computer.
It is strongly recommended that you exit all Windows programs before running this Setup Program.
Click Cancel to quit Setup and close any programs you have running. Click Next to continue with the Setup program.
WARNING: This program is protected by copyright law and international treaties.
Unauthorized reproduction or distribution of this program, or any portion of it, may result in severe civil and criminal penalties, and will be prosecuted to the maximum extent possible under law.
Next >
Cancel

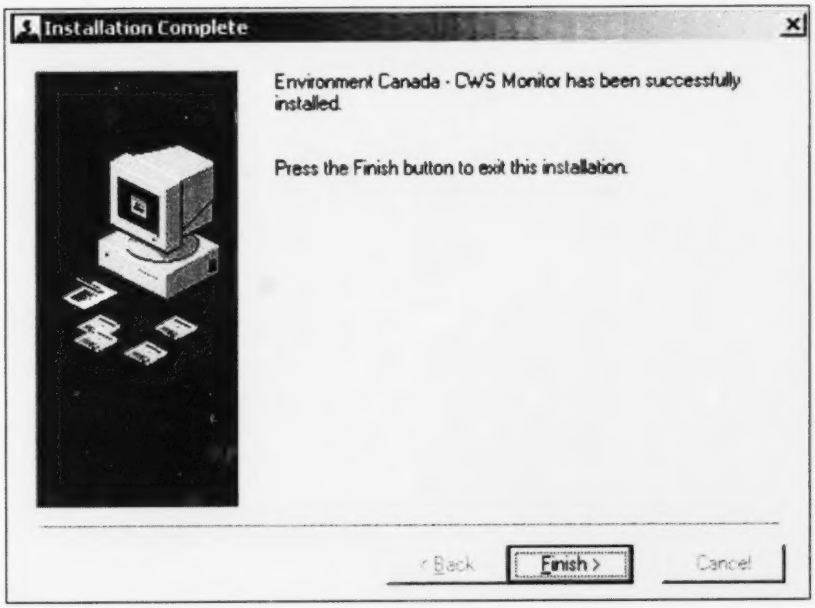
Choose Destination Location
Setup will install Environment Canada - CWS Monitor in the following folder.
To install into a different folder, click Browse, and select another folder.
You can choose not to install Environment Canada - CWS Monitor by clicking Cancel to exit Setup.
Destination Folder
C:\Program Files\CWS Monitor 2
Browse...
< Back
Next >
Cancel

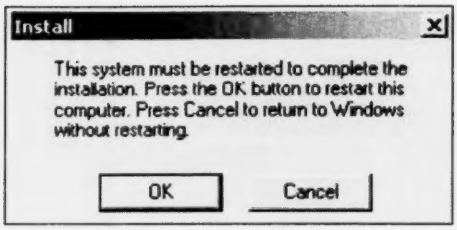
Update ArcView's Default Project
ArcView's default project (default.apr) contains errors that may cause CWS monitor to have problems communicating with ArcView. Replacing the default.apr will allow CWS monitor to operate correctly but may overwrite customizations you have made to ArcView's default project. Unless you know you have made customizations, you should probably select the Replace option.
If you select yes, the original will be backed up to C:\ESRI\AV_GIS30\ARCVIEW\etc\default.apr.bak
Yes
No
< Back
Next >
Cancel


Select Program Manager Group
Enter the name of the Program Manager group to add Environment Canada - CWS Monitor icons to:
CWS Monitoring Programs
Accessories
Adaptec Easy CD Creator 4
Administrative Tools
Adobe
Adobe Acrobat 4.0
Dell Accessories
ESRI
GPS Pathfinder Office 2.80
HP DeskJet 1220C Printer
Microsoft Office Tools
Patch Analyst
PCI Geomatica V8.0
PCI Geomatics V7.0
Startup
< Back
Next >
Cancel

Start Installation
You are now ready to install Environment Canada - CWS Monitor.
Press the Next button to begin the installation or the Back button to reenter the installation information.
< Back
Next >
Cancel


Installing
Current File
Copying file:
C:\...\CWS Monitor 2\AVData\Lakes.shp
All Files
Time Remaining 0 minutes 2 seconds
< Back
Next >
Cancel


Installation Complete
Environment Canada - CWS Monitor has been successfully installed.
Press the Finish button to exit this installation.
< Back
Finish >
Cancel


Install
This system must be restarted to complete the installation. Press the OK button to restart this computer. Press Cancel to return to Windows without restarting.
OK
Cancel

The Mapping of Monitoring Programs application is now ready to be used.

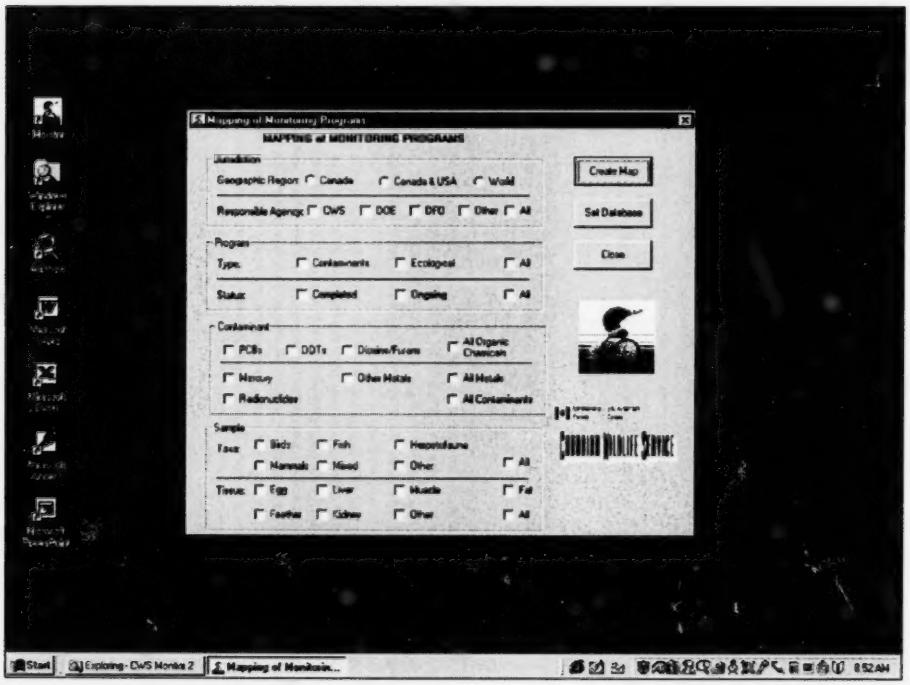
Step 2: Activate the custom user interface

Find the application named monitor.exe.

C:\Program Files\CWS Monitor 2\monitor.exe

Activate the monitor.exe application (left click 2x) to open the Mapping of Monitoring Programs window.

Monitor.exe

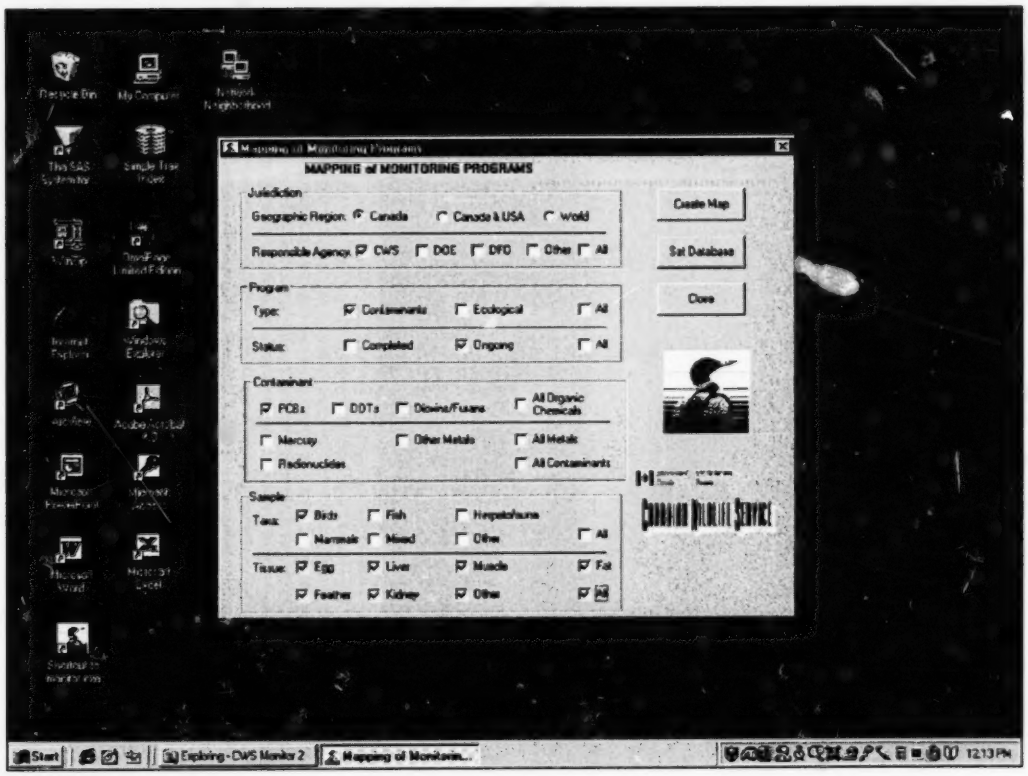


This is the Mapping of Monitoring Programs window (refer to Glossary for criteria definitions).

Step 3: Set criteria and use the Mapping of Monitoring Programs window to generate an ArcView GIS display.

Select criteria in each of the possible categories.

Example:	*Category*	*Criteria*
	Geographic Region	Canada
	Responsible Agency	CWS
	Program Type	Contaminants
	Program Status	Ongoing
	Contaminant	PCBs
	Sample Taxa	Birds
	Sample Tissue	All


MAPPING of MONITORING PROGRAMS
Jurisdiction
Geographic Region: Canada | Canada & USA | World
Responsible Agency: CWS | DOE | DFO | Other | All
Program
Type: Contaminants | Ecological | All
Status: Completed | Ongoing | All
Contaminant
PCBs | DDTs | Dioxins/Furans | All Organic Chemicals
Mercury | Other Metals | All Metals
Radionuclides | All Contaminants
Sample
Taxa: Birds | Fish | Herpetofauna | Mammals | Mixed | Other | All
Tissue: Egg | Liver | Muscle | Fat | Feather | Kidney | Other | All
Create Map
Set Database
Close

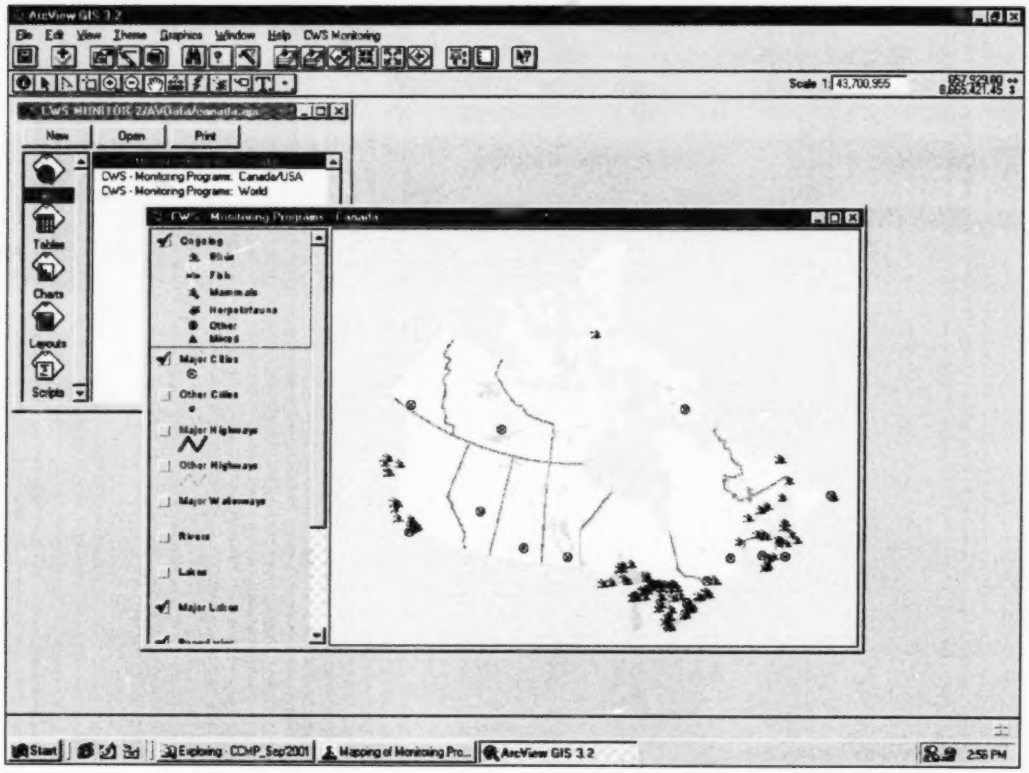
Except for "Sample Tissue", at least one criterion must be selected in each category to activate the Mapping of Monitoring Programs window. By selecting "All" for "Tissues", only projects where tissues were sampled will appear in the geographic display.

Left click on the "Create Map" button. This will activate ArcView independently and create the desired map.

The map and associated tables generated in the ArcView project will reflect the criteria set in the Mapping of Monitoring Programs window.

The map generated with these criteria will be used for demonstration in the rest of this document.

Tip: Use the Help tool in ArcView at any time during your exploration of the Canadian Contaminant Monitoring Project Assessment (CCMPA)



This view depicts all ongoing CWS contaminant monitoring programs in Canada involving avian species. Each bird icon designates a location for avian monitoring. Use the zoom in and zoom out tools to focus on a particular area of interest. It s hould be noted that for all taxa types, some icons may designate the centroid of a polygon rather than a point sampling location.

Behind this view is ArcView's project window. Down the left side are 5 different document types: Views, Tables, Charts, Layouts, and Scripts. The menus, buttons, and tools displayed at the top of the ArcView window alter according to which document type is active. In this project, only Views and Tables will be used.

The "Views" window lists 3 views which are contained within CWS Monitor's project.

View 1: CWS - Monitoring Programs: Canada
View 2: CWS - Monitoring Programs: Canada/USA
View 3: CWS - Monitoring Programs: World

The view generated depends on which of the three Geographic Regions is selected in the Mapping of Monitoring Programs window.

In this example, "Canada" is selected so "View 1: CWS – Monitoring Programs: Canada" is displayed.

A view is composed of one or more themes. A theme is what you see in a view. Available themes are found in the TOC (Table of Contents), or legend, displayed on the left side of the view. In the view shown above, the Ongoing projects is a single theme, although it has multiple symbols (1 for each Sample Taxa).

The following is a list of themes available in the CWS - Monitoring Programs: Canada view.

Themes:

Completed and/or Ongoing Projects
Major Cities
Other Cities
Major Highways
Other Highways
Major Waterways
Rivers
Lakes
Major Lakes
Boundaries
Terrestrial Ecozones of Canada
Terrestrial Ecoregions of Canada
Terrestrial Ecodistricts of Canada
Canada

Not all themes in the "CWS - Monitoring Programs: Canada" view are activated when the "Create Map" function is selected. A checkmark indicates that the theme is "active". A theme is "active" when it is being displayed in the view. A theme can be added or removed from the view by checking or un-checking the box in the TOC.

For example, you may wish to add the Terrestrial Ecozones of Canada when examining features displayed for avian CWS ongoing programs in Canada.

The Terrestrial Ecozones of Canada theme is displayed beneath the Ongoing Projects theme.

Basic Operation of ArcView

Step 4: Extracting information from the view

A theme consists of features and their corresponding attributes. Each feature has a location, shape, and symbol that represent one or more of its characteristics. For example, each bird image depicted in the view is considered a single feature.

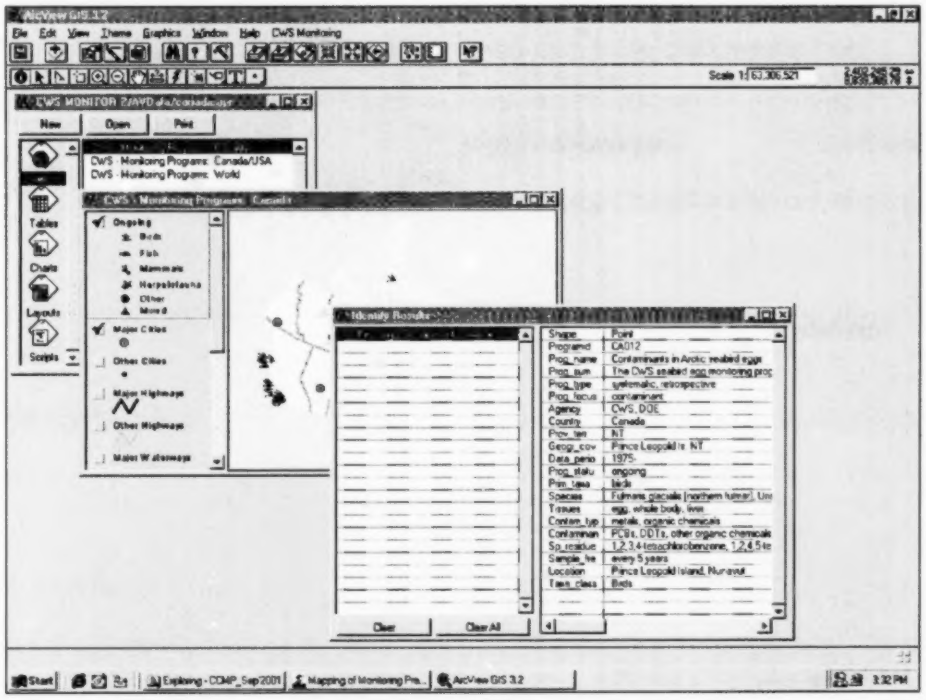
A theme's information is stored in a theme attribute table. Each feature has a corresponding record in the theme table. Each field in the table represents a single attribute for that feature.

There are several methods of extracting data displayed in a view. To begin, the theme must be raised in the table of contents. To do this, simply left click on the theme of interest.

(i) Accessing data with the Identity Tool

The Identify tool is a quick and simple method for extracting the attributes (information) for a particular feature (record). To access this information, click on the Identify tool and then click on any feature with the mouse. ArcView will then produce an Identify Results Pop Up window that displays the attribute data.

In this view, each bird image represents a feature. A single bird image was selected with the Identify tool.



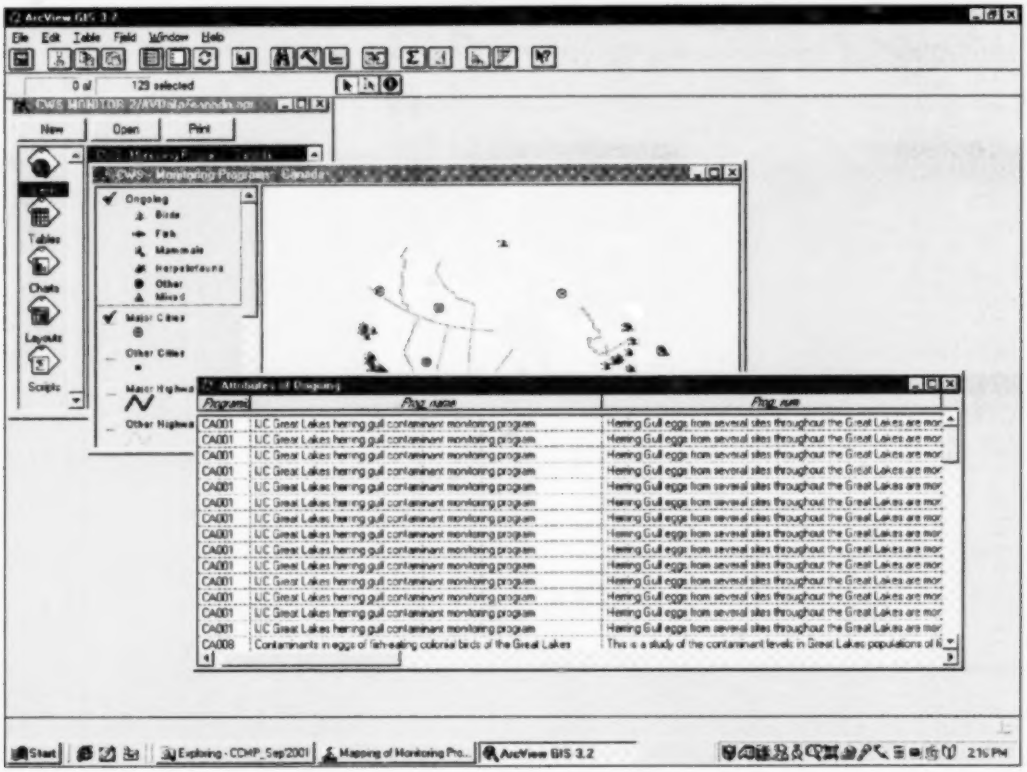
This action generated an Identify Results Pop-up window for this feature. This window displays a single record at a time in table format. The center column includes all the fields within the theme table and to the right are the corresponding attributes.

If more than one feature (more than one record) occurs at the same point, they will all be displayed in the Identify Results window. However, only one record at a time is completely displayed.

Note: There is a limit to the amount of data that can be viewed in a single cell in the Identify Results window. For total access to data contained within the theme's attribute table, use the following method.

(ii) Access data with the Open Theme Table command

With the theme of interest raised in the TOC, use the Open Theme Table button to open the associated theme attribute table.



This table contains attributes for the Ongoing Projects theme. Scroll left and right, and widen the field widths to explore the database. The number of records contained within the table is indicated in the top left corner of the ArcView window. Here, 129 records are contained within the Ongoing Programs theme attribute table.

It is evident that most programs display multiple records. This is because each identified monitoring location appears as a single feature in the view.

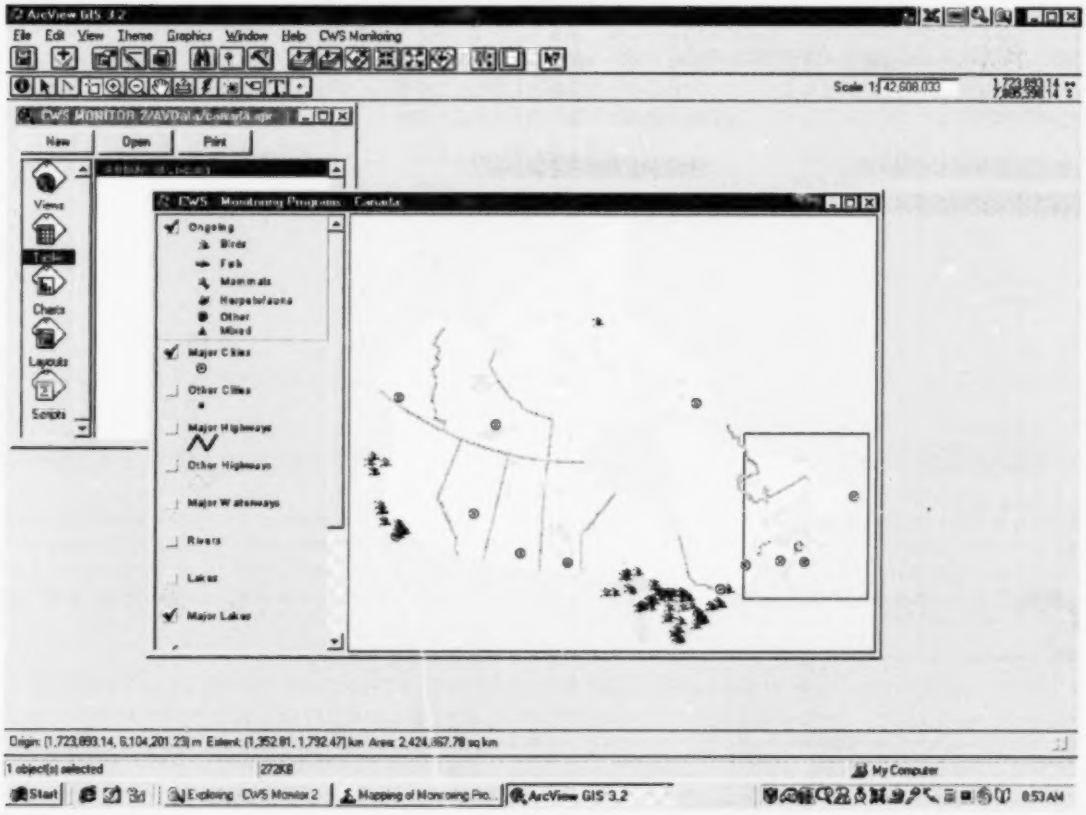
Step 5: Selecting and querying data in the view and attribute table

Data can be selected in either the view or the attribute table. If you select a feature in the view, the corresponding record in the attribute table will also be selected. Selected records in either are highlighted in yellow. Features that have been selected remain selected until you have made another selection or have cleared the selected features.

There are various ways of selecting records.

(i) Use the Select Feature Tool

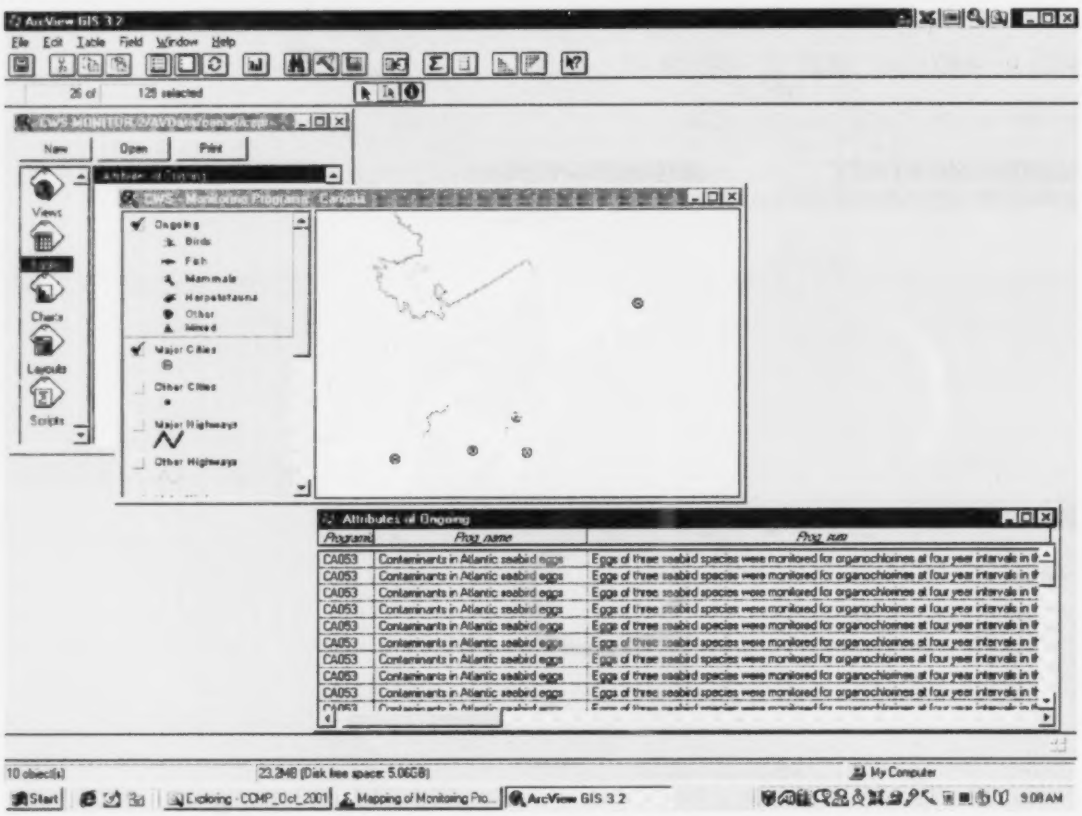
In the view, go to the task bar and click on the Select Feature tool . Draw a box around the bird images (features) depicted in the Atlantic region to highlight programs occurring in this area.



Use the Zoom to Selected tool to get a better view of the highlighted records. Again, the Ongoing theme in the TOC must be raised to zoom into the selected features.

Open the theme table to see which records are associated with the highlighted features in the view.

The top left hand corner shows that there are 26 (of 129) locations identified as monitoring locations in the Atlantic Region.



Selecting features in either the view or theme table will concurrently do the same in the other i.e. selecting a record in the theme table will result in the selection of the corresponding feature in the view.

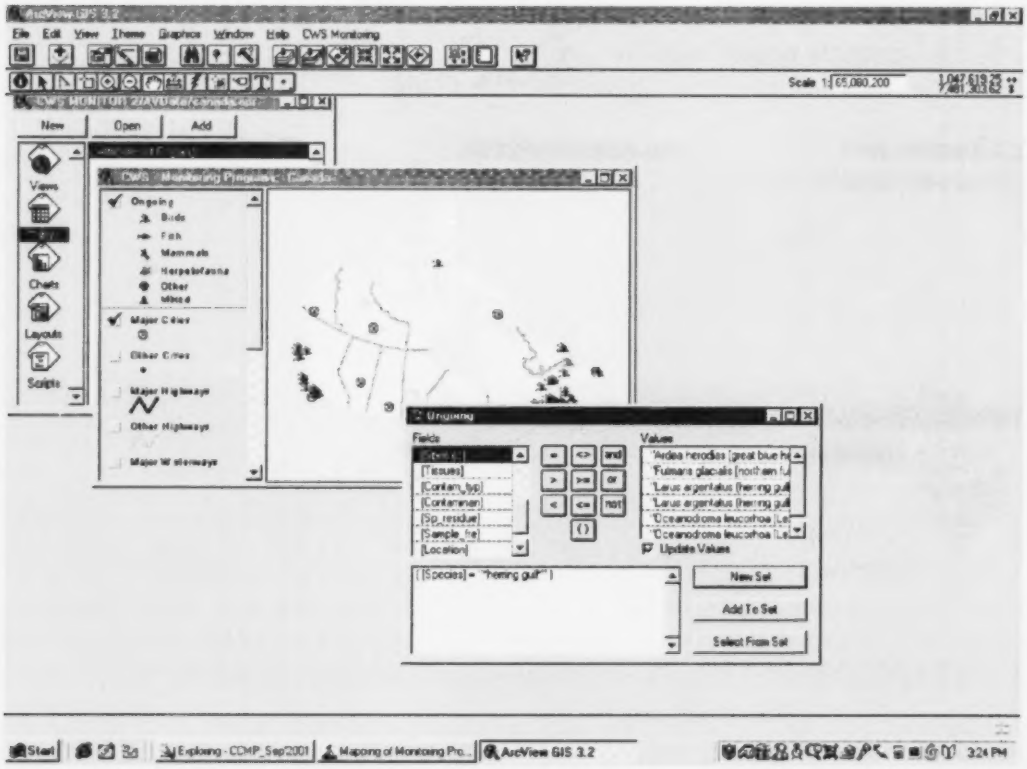
Use the Select None button or click the pointer in a blank part of the view to clear the selected features.

(ii) Use the Query Builder

The Query Builder can be used in the view or attribute table to select specific records. For example, you can find all ongoing programs where herring gull are a monitored species.

Query: ([Species] = "*herring gull*")

When you define a query, you can use any combination of attribute values to select a set of features.



Hit the "New Set" button to activate the Query Builder. If finished, close the query window.

Open the theme table and hit the Promote button so that all selected (highlighted) records are shifted to the top of the table.

Zoom to the selected records to see where this species is studied in Canada.

Scrolling through the theme table reveals that there are 2 ongoing CWS contaminant programs (CA001 & CA008) which use the herring gull as a monitoring species.

Step 6: Close the project

The close the CWS Monitor application, simply close the Mapping of Monitoring Programs window and Close the ArcView project window.

When prompted to "Save Changes" in ArcView, hit "No".

Error messages!

If the Mapping of Monitoring Programs user interface and/or ArcView software generates error messages or is not working properly, simply exit both programs and reactivate the user interface before attempting another query. If difficulty persists, remove all CWS Monitor files and try reinstalling the program.

Exiting the CCMPA application

When choosing to exit the Mapping of Monitoring Program's user interface and ArcView project, simply close each window and select "No" when prompted to save any changes to the project.

Glossary

Archiving - the availability of samples for retrospective analysis

Contact Name - the individual or group responsible for the database

Contaminant - the main contaminant(s) studied

Data Acquisition Methods - the method of sample collection and analysis

Database Size - the number of records contained within the database

Data Storage - the format of data storage

Geographic Coverage - the range and locations of sampling

Herpetofauna - refers to amphibian or reptilian taxa

Jurisdiction - the geographic region in which the monitoring program extends over

Latitude - the latitude of the location in decimal degrees

Location Name - the name of the sampling location

Longitude - the longitude of the location in decimal degrees

Mixed - as used in the "Taxa" category of the user interface, refers to all unspecified taxa
- it does not refer to a combination of Taxa groups

No. of Sites - the number of sites monitored

Period of Data - the years of coverage of the program

Primary Taxa - the taxonomic group of primary interest

Program Focus -the nature or focus of the program, either contaminant or ecologically based
- referred to as "Program Type" in the interface

ProgramID - code of the form 'aa-###' where

(i) "aa" - refers to a jurisdiction (AS = Asia, CA = Canada, EU = Europe, IN = International, US = USA)
(ii) "###" - is a sequential numbering scheme

Program Name - the official name of the program

Program Status - whether monitoring for a particular program is ongoing or terminated at any given site

Program Summary - a short description of the program, including its major objectives

Program Type - as used in the database, a description of the nature of the program

(i) *Systematic* - a designed monitoring program
(ii) *Opportunistic* - monitoring using available samples (e.g. using found moribund animals)
(iii) *Review* - time trend established by reviewing pre-existing work
(iv) *Retrospective* - using archived bank or museum material to reanalyze contaminant levels

- as used in the custom interface, refer to the definition for "*Program Focus*"

Responsible Agency - the agency responsible for conducting the program

Sampling Frequency - frequency of sample collection (i.e. monthly or seasonally)

Species - species sampled

Specific Residues - chemical residues sampled

Tissue Bank Location - location of archived tissues

Tissues - tissues and other matrices sampled or analyzed

Variables - other data collected

Comments - additional information concerning the database

Note: The terms used may vary slightly between the user interface, database, and ArcView theme tables.

Procédure d'installation et d'utilisation de inst_ccmpa.exe

Exigences du programme

Les logiciels ArcView 3.2 GIS et Microsoft Access 95 sont nécessaires pour installer et utiliser inst_ccmpa.exe.

Que contient ce document?

(i) La procédure d'installation de l'application inst_ccmpa.exe : Étapes 1 à 3;

(ii) Les principes d'utilisation de base du logiciel ArcView pour les requêtes plus complexes: Étapes 4 à 6.

Comment fonctionne le programme inst_ccmpa.exe?

L'application inst_ccmpa.exe comporte trois composants fonctionnant conjointement de façon interactive. L'organigramme suivant indique comment l'information est acheminée d'un composant à l'autre.

Fenêtre Mapping of Monitoring Programs
les critères sont sélectionnés

↓

Accès à la base de données - ccmpa_gis.mdb
les dossiers sont interrogés

↓

logiciel de cartographie ArcView GIS
la carte est générée et les données sont affichées

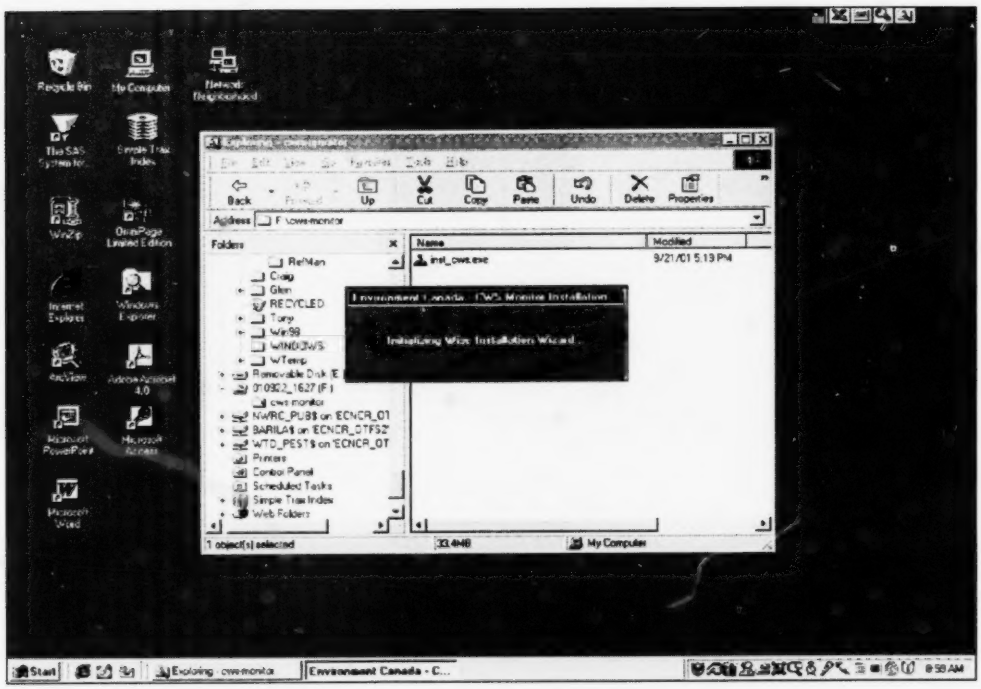
Installation du programme

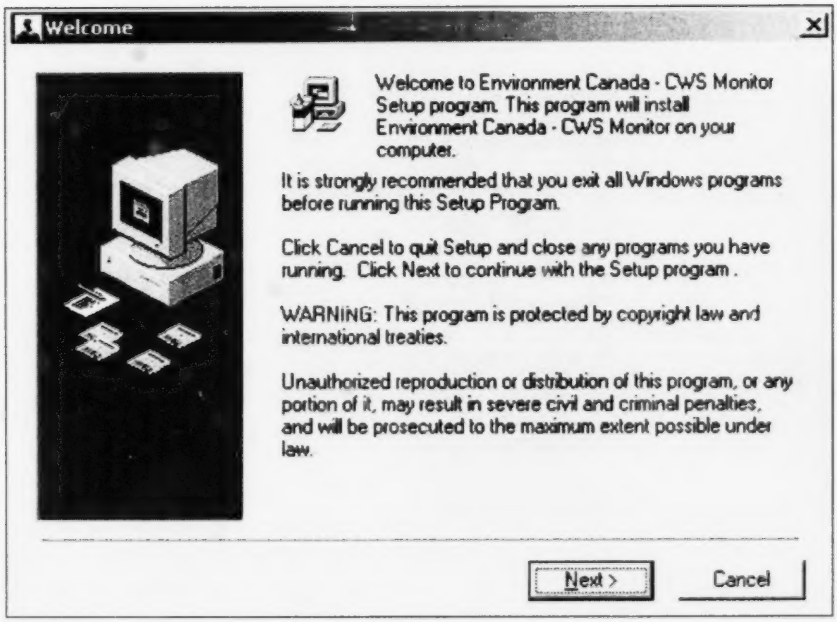
1re étape : Installer l'application Mapping of Monitoring Programs

Insérez le disque compact CCMPA dans votre lecteur de disques compacts. Dans l'explorateur Windows, repérez l'application inst_ccmpa.exe et cliquez deux fois à l'aide du bouton gauche de la souris pour lancer le processus d'installation.

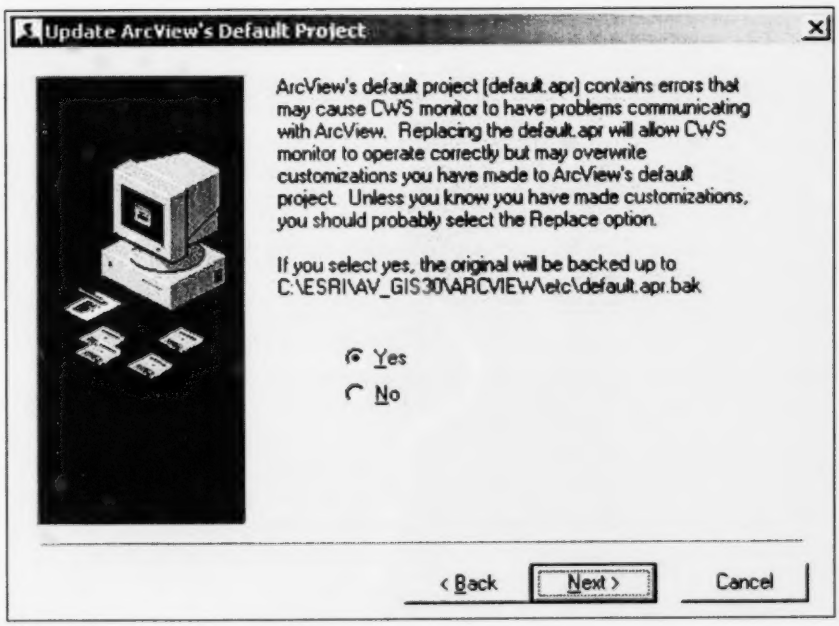
Les images suivantes représentent les fenêtres qui devraient s'afficher l'une après l'autre. Choisissez « Next » pour continuer et « Finish » pour terminer l'installation.

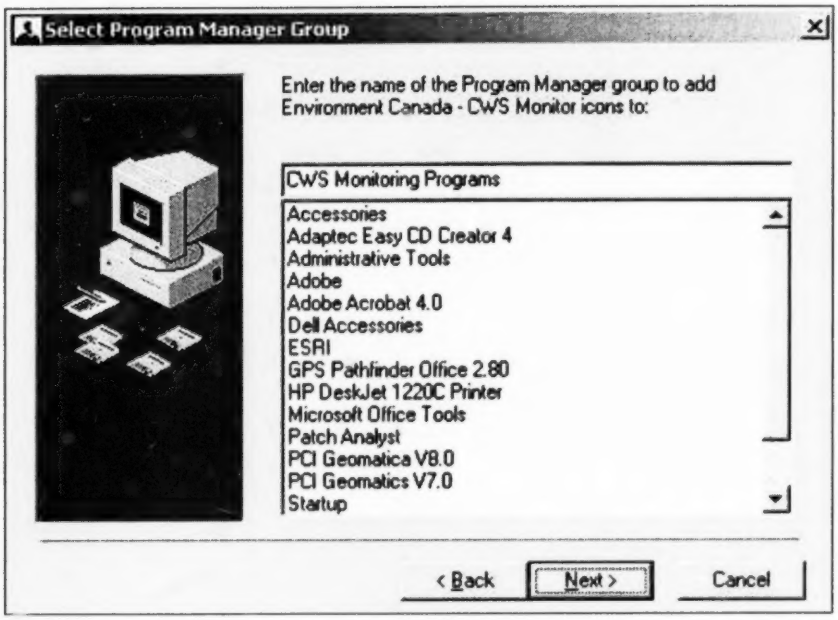
Remarque : Choisissez « Cancel » pour quitter la procédure d'installation.



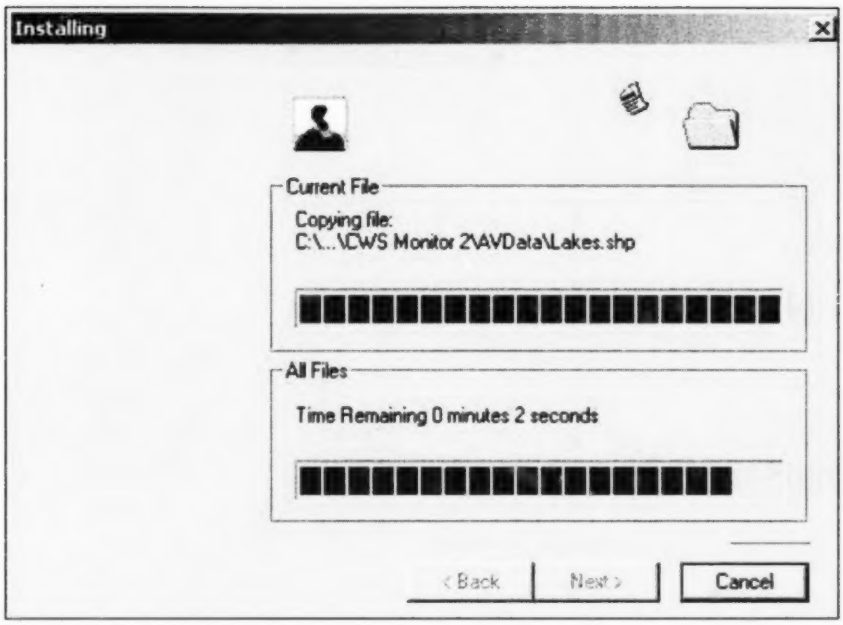

Welcome
Welcome to Environment Canada - CWS Monitor Setup program. This program will install Environment Canada - CWS Monitor on your computer.
It is strongly recommended that you exit all Windows programs before running this Setup Program.
Click Cancel to quit Setup and close any programs you have running. Click Next to continue with the Setup program .
WARNING: This program is protected by copyright law and international treaties.
Unauthorized reproduction or distribution of this program, or any portion of it, may result in severe civil and criminal penalties, and will be prosecuted to the maximum extent possible under law.
Next >
Cancel

Choose Destination Location
Setup will install Environment Canada - CWS Monitor in the following folder.
To install into a different folder, click Browse, and select another folder.
You can choose not to install Environment Canada - CWS Monitor by clicking Cancel to exit Setup.
Destination Folder
C:\Program Files\CWS Monitor 2
Browse...
< Back
Next >
Cancel

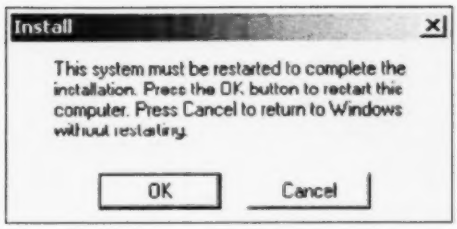

Update ArcView's Default Project
ArcView's default project (default.apr) contains errors that may cause CWS monitor to have problems communicating with ArcView. Replacing the default.apr will allow CWS monitor to operate correctly but may overwrite customizations you have made to ArcView's default project. Unless you know you have made customizations, you should probably select the Replace option.
If you select yes, the original will be backed up to C:\ESRI\AV_GIS30\ARCVIEW\etc\default.apr.bak
Yes
No
< Back
Next >
Cancel


Select Program Manager Group
Enter the name of the Program Manager group to add Environment Canada - CWS Monitor icons to:
CWS Monitoring Programs
Accessories
Adaptec Easy CD Creator 4
Administrative Tools
Adobe
Adobe Acrobat 4.0
Dell Accessories
ESRI
GPS Pathfinder Office 2.80
HP DeskJet 1220C Printer
Microsoft Office Tools
Patch Analyst
PCI Geomatica V8.0
PCI Geomatics V7.0
Startup
< Back
Next >
Cancel

Start Installation
You are now ready to install Environment Canada - CWS Monitor.
Press the Next button to begin the installation or the Back button to reenter the installation information.
< Back
Next >
Cancel


Installing
Current File
Copying file:
C:\...\CWS Monitor 2\AVData\Lakes.shp
All Files
Time Remaining 0 minutes 2 seconds
< Back
Next >
Cancel

Installation Complete
Environment Canada - CWS Monitor has been successfully installed.
Press the Finish button to exit this installation.
< Back
Finish >
Cancel


Install
This system must be restarted to complete the installation. Press the OK button to restart this computer. Press Cancel to return to Windows without restarting.
OK
Cancel

L'application Mapping of Monitoring Programs est maintenant prête à utiliser.

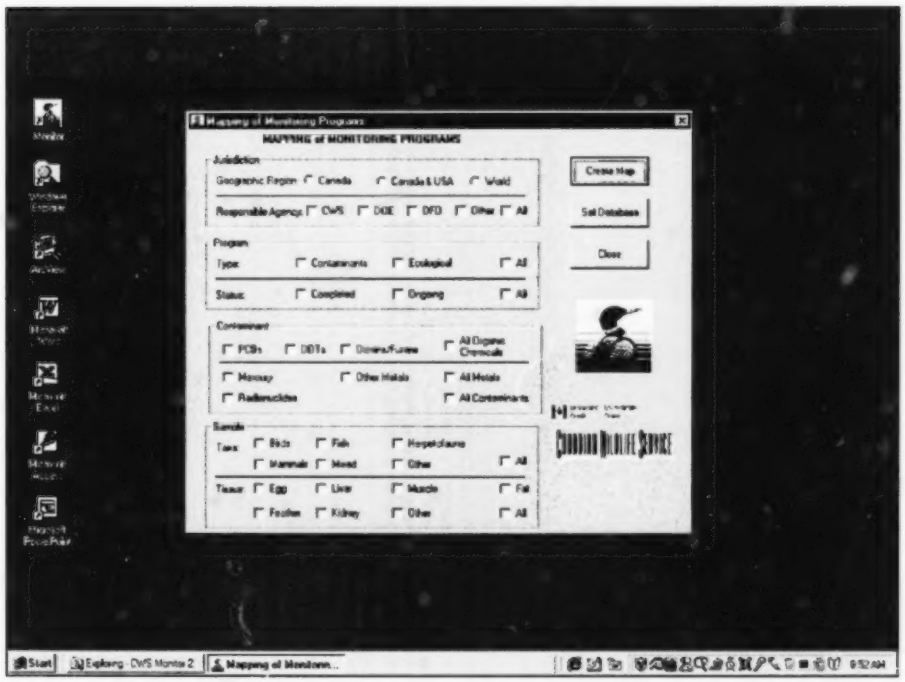
2e étape : Activer l'interface utilisateur personnalisée

Repérez l'application nommée monitor.exe.

C:\Program Files\CWS Monitor 2\monitor.exe

Démarrez l'application monitor.exe (cliquez 2 fois à l'aide du bouton gauche de la souris) pour ouvrir la fenêtre Mapping of Monitoring Programs.

Monitor.exe

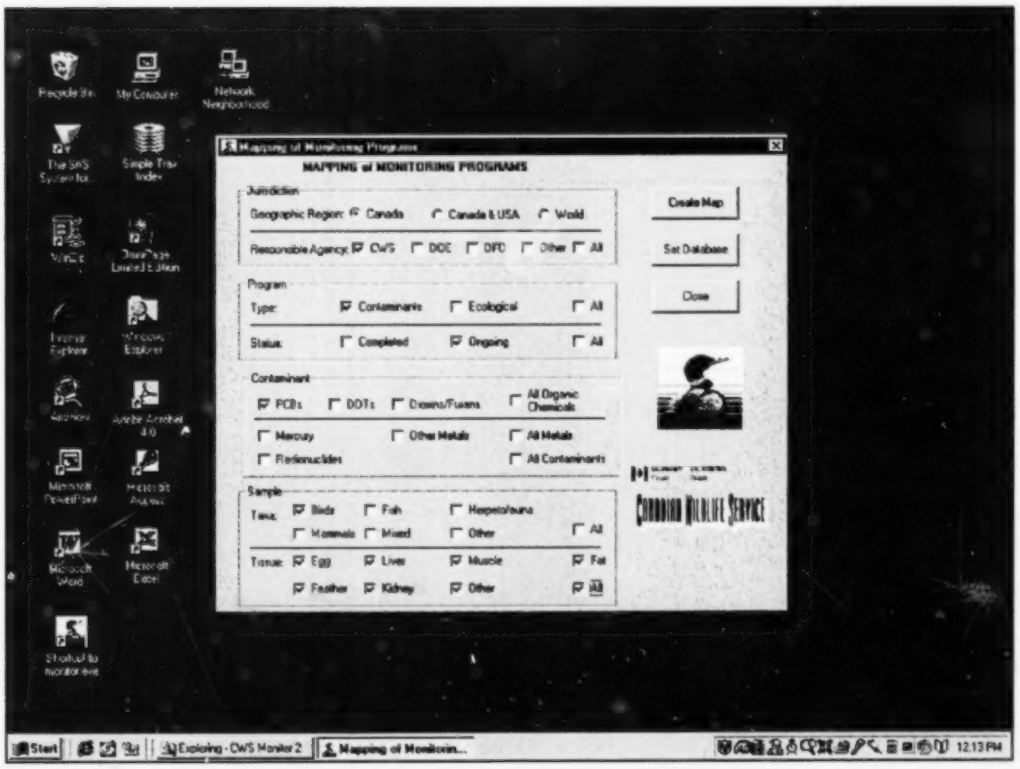


Voici la fenêtre Mapping of Monitoring Programs
(reportez-vous au glossaire pour la définition des critères)

3e étape : Déterminer les critères et utiliser la fenêtre Mapping of Monitoring Programs pour créer un affichage ArcView GIS.

Choisissez un critère dans chacune des catégories.

Exemple :	*Catégories*	*Critères*
	Geographic Region	Canada
	Responsible Agency	CWS
	Program Type	Contaminants
	Program Status	Ongoing
	Contaminant	PCBs
	Sample Taxa	Birds
	Sample Tissue	All



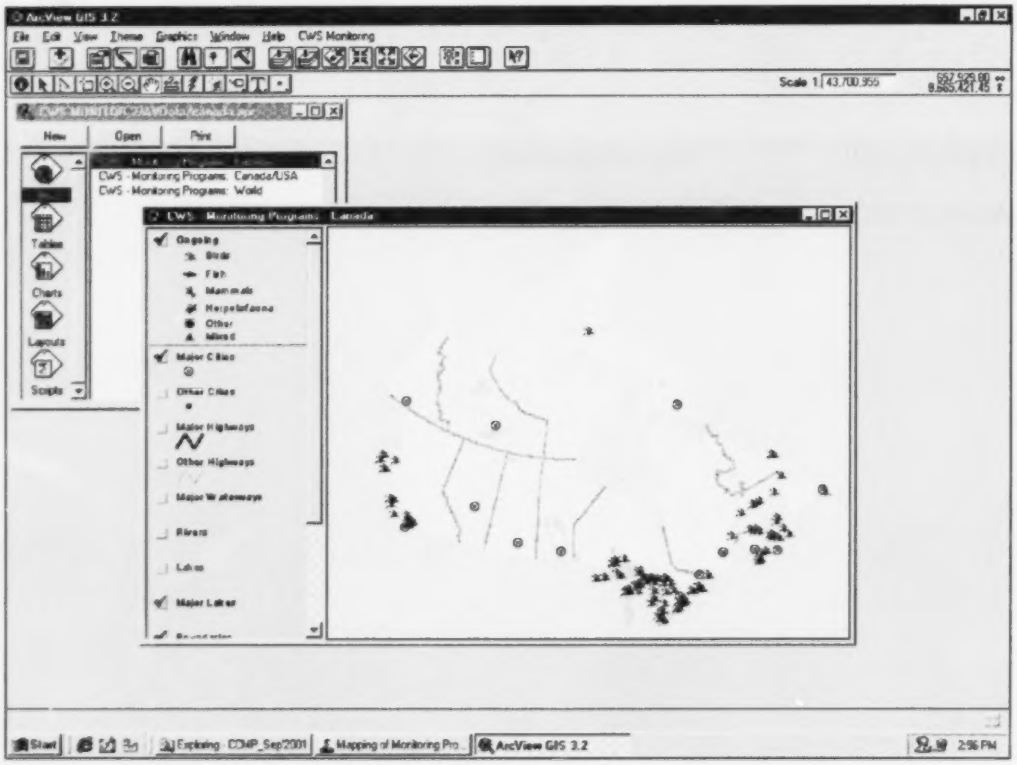
Au moins un critère doit être sélectionné dans chaque catégorie pour activer la fenêtre Mapping of monitoring Programs, à l'exception de la catégorie « Sample Tissue ». Si vous choisissez « All » dans la catégorie « Tissues », les projets qui apparaîtront sur la carte géographique seront uniquement ceux dans lesquels des échantillons de tissus auront été prélevés.

Cliquez sur le bouton Create Map avec le bouton gauche de la souris pour activer ArcView de façon indépendante et créer la carte désirée.

La carte et les tableaux afférents générés dans le projet ArcView correspondront aux critères sélectionnés dans la fenêtre Mapping of Monitoring Programs.

La carte générée d'après ces critères servira d'exemple pour le reste du présent document.

Conseil : Utilisez l'outil d'aide d'ArcView à tout moment pendant votre exploration de l'évaluation canadienne du projet de contrôle des contaminants (Canadian Contaminant Monitoring Project Assessment - CCMPA).



Cet affichage présente tous les programmes de surveillance des contaminants du SCF en cours au Canada, qui touche des espèces aviaires. Chaque icône d'oiseau indique un site de surveillance aviaire. Utilisez le zoom avant et le zoom arrière pour examiner une zone d'intérêt particulière. Veuillez noter que, pour tous les types de taxons, certains icônes peuvent désigner le centre géométrique d'un polygone plutôt qu'une zone d'échantillonnage systématique.

Derrière cet affichage se trouve la fenêtre de projet ArcView. Cinq types de documents sont énumérés le long du côté gauche : Views, Tables, Charts, Layouts et Scripts. Les menus, les

boutons et les outils affichés dans la partie supérieure de la fenêtre ArcView changent selon le type de document qui est actif. Seuls les types Views et Tables seront utilisés pour ce projet.

La fenêtre « Views » énumère trois affichages faisant partie du projet du CWS Monitor.

Affichage 1 : CWS – Monitoring Programs: Canada
Affichage 2 : CWS – Monitoring Programs: Canada/USA
Affichage 3 : CWS – Monitoring Programs: World

L'affichage généré dépend de la région géographique qui a été sélectionnée dans la fenêtre Mapping of Monitoring Programs.

Dans cet exemple, « Canada » est sélectionné, alors « CWS – Monitoring Programs: Canada » est affiché.

Un affichage est composé d'un ou de plusieurs thèmes. Un thème est ce que vous voyez dans un affichage. Les thèmes disponibles sont indiqués dans la table des matières (ou légende) située du côté gauche de l'affichage. Sur l'affichage ci-dessus, les projets Ongoing (en cours) constituent un seul thème même s'il comporte plusieurs symboles (un pour chaque taxon échantillonné).

Voici une liste des thèmes disponibles dans l'affichage CWS – Monitoring Programs: Canada.

Thèmes :

Completed and/or Ongoing Projects
Major Cities
Other Cities
Major Highways
Other Highways
Major Waterways
Rivers
Lakes
Major Lakes
Boundaries
Terrestrial Ecozones of Canada
Terrestrial Ecoregions of Canada
Terrestrial Ecodistricts of Canada
Canada

Les thèmes ne sont pas tous activés dans l'affichage « CWS – Monitoring Programs: Canada » lorsque la fonction Create Map est activée. Un thème est « activé » lorsqu'il est précédé d'un crochet et qu'il est affiché. Il est possible d'ajouter un thème à l'affichage ou d'en enlever un en cochant ou en décochant la case correspondante dans la table des matières.

Vous pourriez, par exemple, désirer ajouter le thème « Terrestrial Ecozones of Canada » dans le cadre de votre examen des éléments des programmes du SCF en cours au Canada touchant des espèces aviaires.

Le thème « Terrestrial Ecozones of Canada » est affiché sous le thème « Ongoing Projects ».

Fonctionnement de base d'ArcView

4e étape : Extraire l'information de l'affichage

Un thème est constitué d'éléments et d'attributs correspondants. Chaque élément est associé à un site, à une forme et à un symbole qui représente une de ses caractéristiques ou plus. Par exemple, chaque image d'oiseau illustrée dans l'affichage est considérée comme un élément unique.

L'information associée à un thème est stockée dans un tableau des attributs du thème. Chaque élément possède un enregistrement correspondant dans ce tableau. Chaque champ du tableau contient un seul attribut de cet élément.

Il existe plusieurs méthodes pour extraire les données présentées dans un affichage. D'abord, le thème doit être mis en évidence dans la table des matières. Pour ce faire, il suffit de cliquer sur le thème désiré.

(i) Accéder aux données grâce à l'outil « Identify »

L'outil « Identify » constitue une méthode simple et rapide pour extraire les attributs (information) d'un élément donné (enregistrement). Pour accéder à cette information, cliquez sur l'outil « Identify », puis cliquez sur n'importe quel élément. ArcView créera alors une fenêtre instantanée Identify Results présentant les données relatives aux attributs.

Dans cet affichage, chaque image d'oiseau représente un élément. Une seule image d'oiseau a été sélectionnée au moyen de l'outil « Identify ».

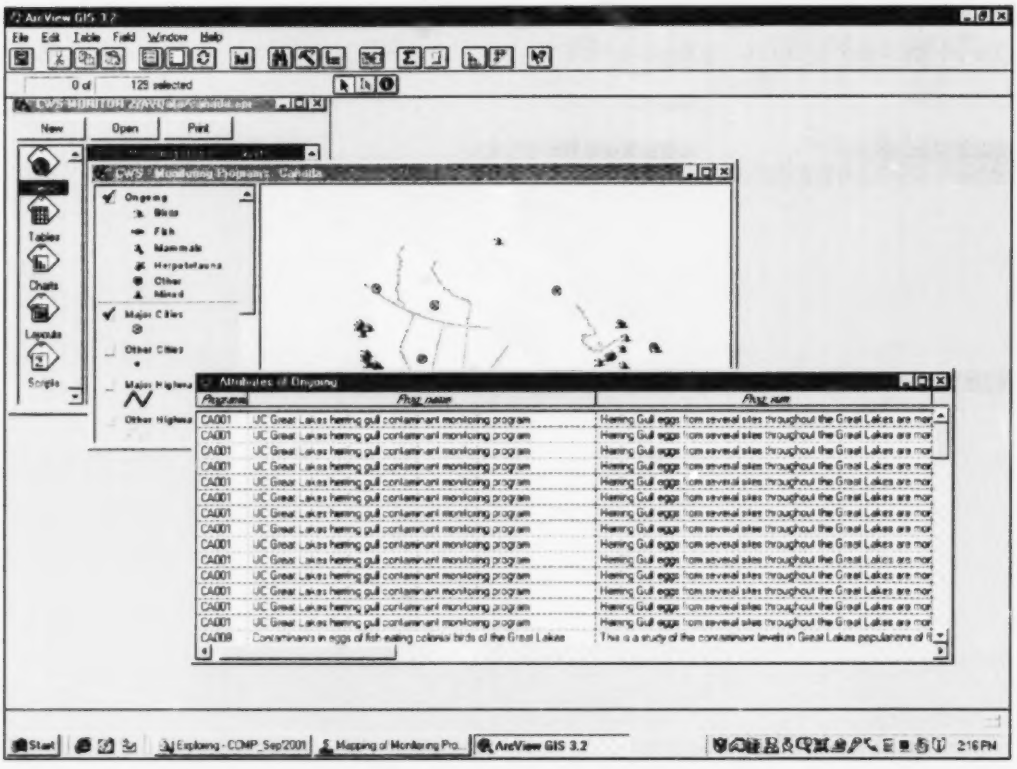
Cette opération a généré une fenêtre instantanée Identify Results pour cet élément. Cette fenêtre affiche un seul enregistrement à la fois sous forme de tableau. La colonne du centre contient tous les champs présentés dans le tableau du thème, et la colonne de droite contient les attributs correspondants.

Si plus d'un élément (plus d'un enregistrement) se produisent au même endroit, ils seront tous affichés dans la fenêtre Identify Results. Cependant, seulement un enregistrement à la fois sera complètement affiché.

Nota : La quantité de données pouvant être affichées dans une cellule de la fenêtre Identify Results est limitée. Pour avoir accès à la totalité des données contenues dans le tableau des attributs du thème, utilisez la méthode suivante :

(ii) Accéder aux données à l'aide de la commande Open Theme Table

Après avoir choisi le thème mis en évidence dans la table des matières, utilisez le bouton Open Theme Table pour ouvrir le tableau des attributs correspondants de l'élément.



Ce tableau contient les attributs du thème « Ongoing Projects ». Faites défiler le tableau vers la gauche et vers la droite et élargissez les champs pour explorer la base de données. Le nombre d'enregistrements contenus dans le tableau est indiqué dans le coin supérieur gauche de la fenêtre ArcView. Dans cet exemple, le tableau des attributs du thème « Ongoing Programs » contient 129 enregistrements.

Il est évident que la plupart des programmes affichent plus d'un enregistrement. Cela est attribuable au fait que chaque site de surveillance identifié est présenté comme élément simple de l'affichage.

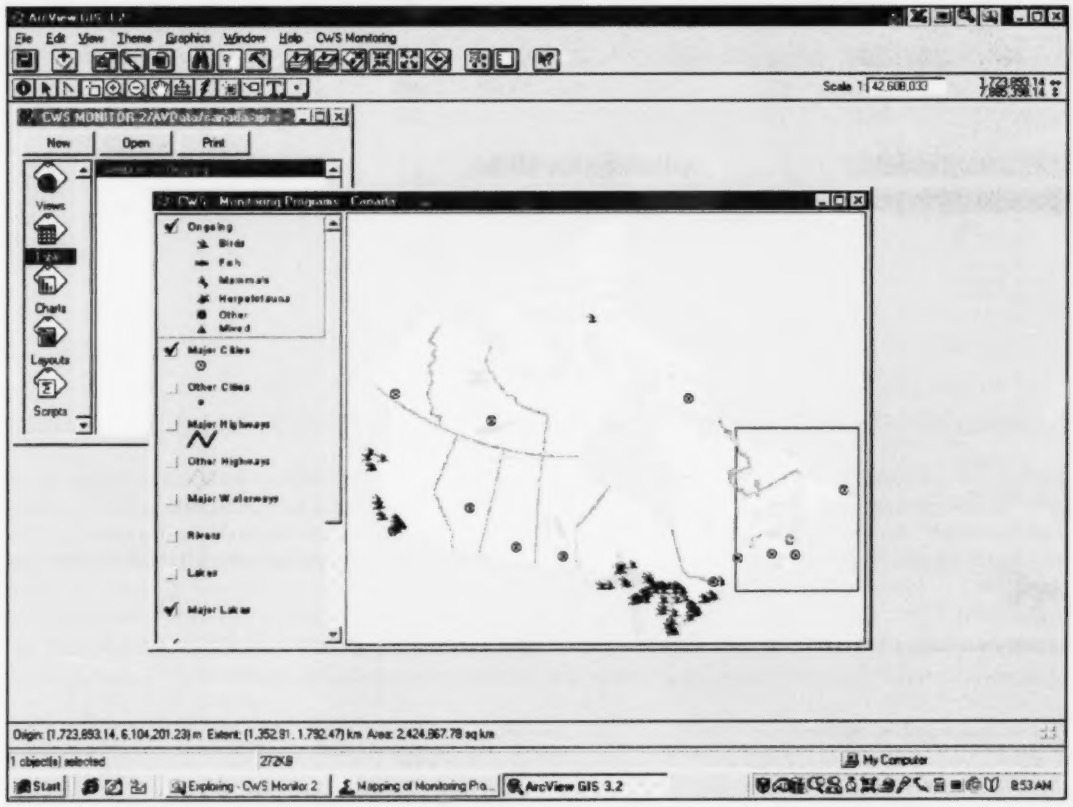
5e étape : Sélectionner et interroger les données dans l'affichage et le tableau des attributs

Les données peuvent être sélectionnées dans l'affichage ou dans le tableau des attributs. Si vous sélectionnez un élément dans l'affichage, l'enregistrement correspondant sera également sélectionné dans le tableau des attributs. Les éléments sélectionnés sont mis en surbrillance jaune. Les éléments sélectionnés le demeurent jusqu'à ce que vous fassiez une nouvelle sélection ou que vous supprimiez les éléments choisis.

Il y a diverses façons de sélectionner des enregistrements.

(i) Utiliser l'outil Select Feature

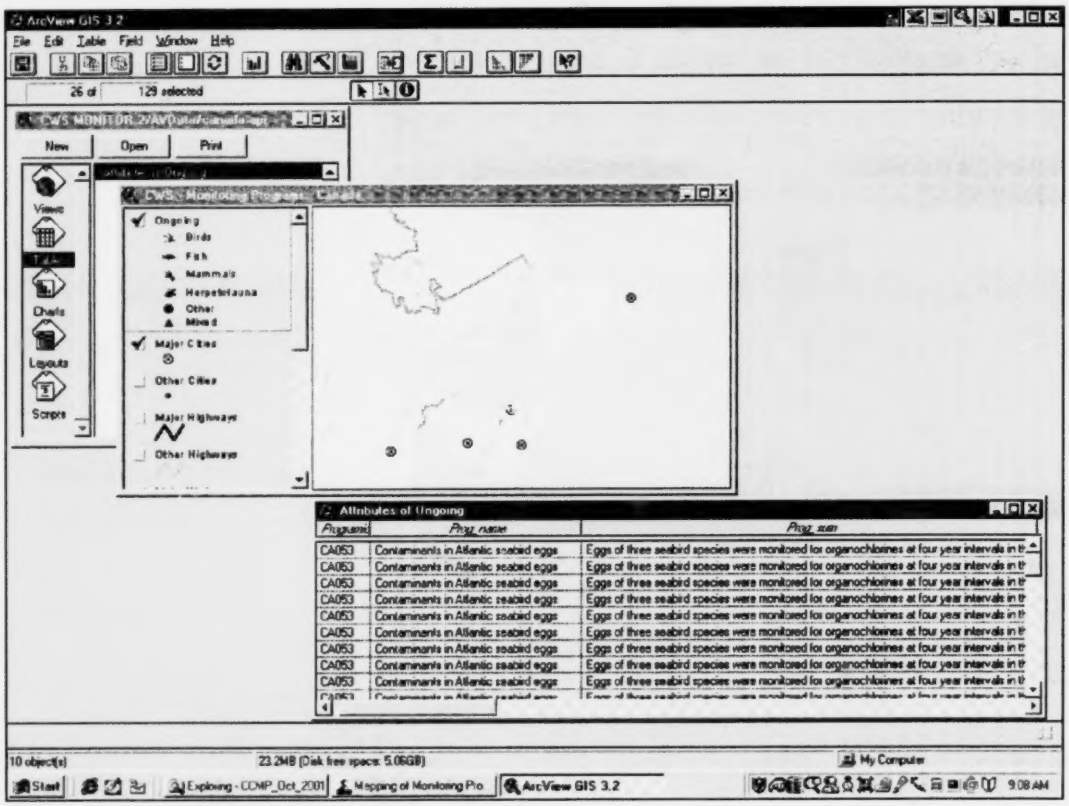
Dans l'affichage, allez à la barre de tâches et cliquez sur l'outil Select Feature . Dessinez ensuite une boîte autour des images d'oiseaux (éléments) situées dans la région de l'Atlantique pour mettre en évidence les programmes qui ont lieu dans cette région.



Utilisez l'outil Zoom to Select pour voir les enregistrements mis en évidence de façon plus détaillée. Le thème « Ongoing » dans la table des matières doit être choisi pour pouvoir faire un zoom sur les éléments sélectionnés.

Ouvrez le tableau des thèmes pour voir quels enregistrements sont associés aux éléments mis en surbrillance dans l'affichage.

Il est indiqué dans le coin supérieur gauche que 26 (des 129) sites sont cernés comme sites de surveillance dans la région de l'Atlantique.



Le fait de choisir des éléments dans l'affichage ou dans le tableau des thèmes entraînera la sélection automatique des éléments correspondants dans l'un ou l'autre. Cela signifie que si vous sélectionnez un enregistrement dans le tableau des thèmes, l'élément correspondant sera automatiquement sélectionné dans l'affichage.

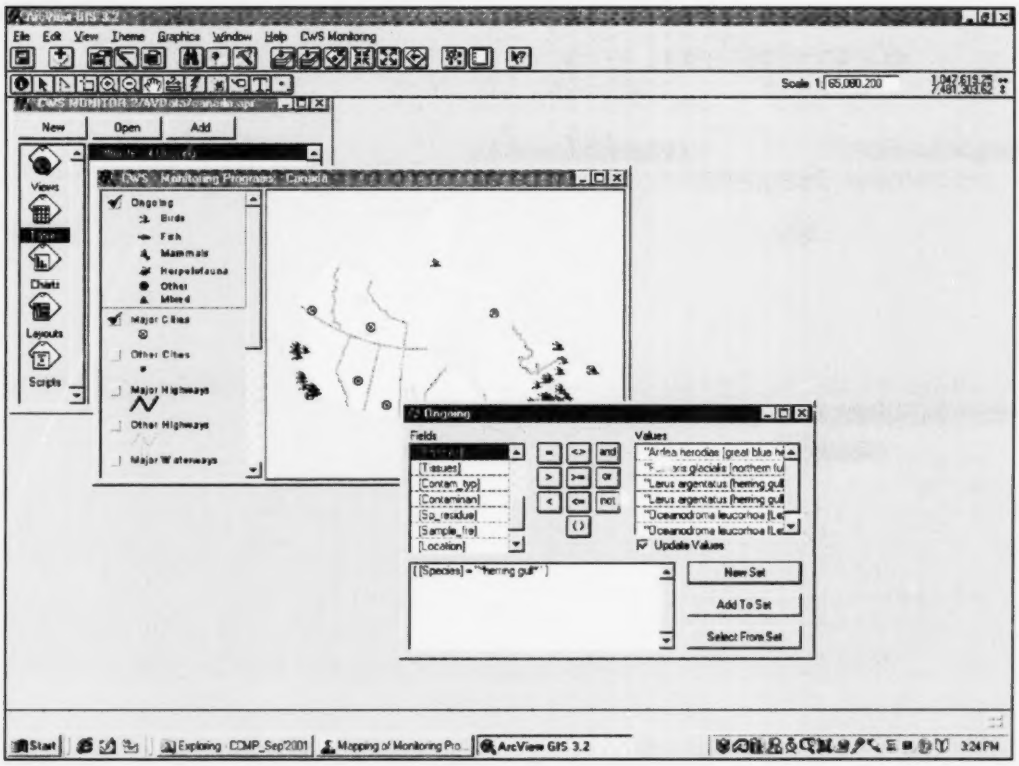
Utilisez le bouton Select None ou cliquez sur un espace vide de l'affichage pour supprimer les éléments sélectionnés.

(ii) Utiliser le Query Builder

Le Query Builder peut être utilisé dans l'affichage ou dans le tableau des attributs pour sélectionner des enregistrements précis. Vous pouvez, par exemple, trouver tous les programmes en cours dans lesquels le Goéland argenté est une espèce surveillée.

Query: ([Species] = "*herring gull*")

Lorsque vous définissez une interrogation, vous pouvez utiliser n'importe quelle combinaison de valeurs d'attributs pour choisir un ensemble d'éléments.



Cliquez sur le bouton New Set pour activer le Query Builder. Fermez la fenêtre d'interrogation lorsque l'opération est terminée.

Ouvrez le tableau des thèmes et cliquez sur le bouton Promote pour que tous les enregistrements sélectionnés (en surbrillance) soient regroupés dans la partie supérieure du tableau.

Faites un zoom avant sur les enregistrements choisis pour voir dans quelles régions du Canada cette espèce fait l'objet d'une étude.

En faisant défiler les éléments du tableau des thèmes, vous pouvez constater qu'il y a deux programmes du SCF en cours portant sur les contaminants (CA001 et CA008) dans lesquels le Goéland argenté est une espèce surveillée.

6e étape : Fermer le projet

Pour quitter l'application CWS Monitor, fermez simplement la fenêtre Mapping of Monitoring Programs et fermez ensuite la fenêtre du projet ArcView.

À l'invite « Save Changes » dans ArcView, cliquez sur « No ».

Messages d'erreur!

Si l'interface utilisateur de Mapping of Monitoring Programs ou le logiciel ArcView envoit des messages d'erreur ou ne fonctionne pas correctement, quittez simplement les deux programmes et relancez l'interface utilisateur avant d'effectuer une nouvelle interrogation. Si le problème persiste, supprimez tous les fichiers de CWS Monitor et tentez de réinstaller le programme.

Quitter l'application CCMPA

Lorsque vous désirez quitter l'interface utilisateur de Mapping of Monitoring Programs et le projet ArcView, fermez simplement chaque fenêtre et cliquez sur « No » lorsqu'on vous demande si vous désirez sauvegarder les changements apportés au projet.

Glossaire

Archiving	- la disponibilité des échantillons pour des analyses rétrospectives
Contact Name	- l'individu ou le groupe responsable de la base de données
Contaminant	- les principaux contaminants à l'étude
Data Acquisition Methods	- la méthode de prélèvement et d'analyse des échantillons
Database Size	- le nombre d'enregistrements que contient la base de données
Data Storage	- le format dans lequel les données sont stockées
Geographic Coverage	- l'aire et l'emplacement des échantillons
Herpetofauna	- fait référence aux taxons d'amphibiens ou de reptiles
Jurisdiction	- la région géographique couverte par le programme de surveillance
Latitude	- la latitude de l'endroit en degrés décimaux
Location Name	- le nom de l'endroit où l'échantillon a été prélevé
Longitude	- la longitude de l'endroit en degrés décimaux
Mixed	- terme utilisé dans la catégorie « Taxa » de l'interface utilisateur, correspond à tous les taxons non précisés - ne s'applique pas à une combinaison de groupes de taxons
No. of Sites	- le nombre de sites surveillés
Période of Data	- la durée du programme en années
Primary Taxa	- le groupe taxinomique d'intérêt principal
Program Focus	- la nature ou le point de concentration du programme : fondé sur l'écologie ou sur les contaminants - appelé « Program Type » dans l'interface
ProgramID	- code du formulaire « aa-### » : (i) « aa » - indique une compétence (AS = Asie, CA = Canada, EU = Europe, IN = International, US = É.-U.) (ii) « ### » - représente un système de numérotation en série
Program Name	- le nom officiel du programme

Program Status	- indique si un programme de surveillance sur un site donné est en cours ou terminé
Program Summary	- une courte description du programme, accompagnée de ses principaux objectifs
Program Type	- terme utilisé dans la base de données, une description de la nature du programme :

(i) *Systematic*	- un programme de surveillance conçu
(ii) *Opportunistic*	- surveillance à l'aide des échantillons disponibles (p. ex. à l'aide d'animaux moribonds trouvés)
(iii) *Review*	- tendance temporelle établie en révisant les travaux préexistants
(iv) *Retrospective*	- utilise les banques d'archives ou du matériel de musées pour réanalyser les niveaux de contamination

- terme utilisé dans l'interface utilisateur, se réfère à la définition de « *Program Focus* »

Responsible Agency	- l'organisme responsable de la mise en œuvre du programme
Sampling Frequency	- fréquence à laquelle les échantillons sont prélevés (p. ex. aux mois ou aux saisons)
Species	- espèces échantillonnées
Specific Residues	- résidus chimiques échantillonnés
Tissue Bank Location	- endroit où se trouvent les tissus archivés
Tissues	- tissus et autres matrices échantillonnés ou analysés
Variables	- autres données recueillies
Comments	- renseignements supplémentaires concernant la base de données

Nota: Les termes utilisés dans l'interface utilisateur, dans la base de données et dans les tableaux de thèmes ArcView peuvent varier légèrement.